A MONOGRAPH

OF THE

BRITISH FOSSIL CEPHALOPODA.

Part I.

INTRODUCTION AND SILURIAN SPECIES.

BY

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NOTICE

AFTER CAREFUL EXAMINATION OF THE INNER MARGIN AND TYPE OF MATERIAL WE HAVE SEWN THIS VOLUME BY HAND SO IT CAN BE MORE EASILY OPENED AND READ.

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PREFACE.

Finding that while there was much confusion as to the species of *Cephalopoda*, especially of the Jurassic rocks, and at the same time much interesting material on which good work had been done on the Continent, I entertained the desire of undertaking a monograph of the group. Two grants from the Government Fund in aid of Scientific Research enabled me to devote the time to collecting the materials from the various museums and private collections in the country; but it soon became evident that nothing short of a detailed description, with figures of the various forms recognised, would be satisfactory: in fact, that I must aim at the standard so admirably set by Mr. Davidson for the *Brachiopoda;* and that though I had collected all the materials for the Devonian and Carboniferous monograph, the first part would have to be restricted to the Silurian, which, with the Introduction, would make a fair-sized volume. This is now (still by the aid of the Government grant) presented to the public, and I hope to be able shortly to produce Part II., which will include the rest of the Palæozoic forms.

It might seem natural that this work should be published by the Palæontographical Society, but I have not asked their acceptance of it—partly because it is well known that they have much more material already offered than their yearly volume can find room for, and any independent work thus renders the day nearer when our British Fossils will be adequately described; and partly because, with the aid I have received from the Government Research Fund, it seems to me only right to test, at least, the demand for such works beyond what is satisfied by the fixed annual amount published by the Palæontographical Society. Still, as the work is strictly of the same kind as that published by the Society, I have made the form and style of printing as nearly as possible similar to their publications.

Whether the original design, which led to the present undertaking, of clearing up the history of the *Jurassic* Cephalopoda, will ever be realised, depends on future circumstances, of which I have no prescience.

The method pursued in working up the present part has been as follows:—I first collected into one book, arranged under the names used by the authors, copies of all the figures given of any British Silurian Cephalopod, or shell supposed to

be such, or subsequently proved so, together with abstracts of everything that had been written on each, and records of the occurrence of the species in any British rock. Where the references were made to foreign species, I also copied the original author's figure and description. With this book in hand, I then visited all the museums and private collections of which I had knowledge as likely to contain Palæozoic Cephalopoda; and of every specimen which appeared to show any character, even though of a well-known species, I took by measurement and careful examination all particulars of size, shape, ornaments, and all other characters, assigning to each specimen a number. I specially sought out the specimens which had been used as types, which for the most part are still accessible, and carefully compared these specimens with all that had been subsequently written about the species, to see how far they coincided. I next copied on to separate sheets the actually observed characters of all the specimens which had been described as belonging, or seemed to belong, to the same species, whereby the wide range of variation which must be allowed under the latter title came out, and the best mode of grouping the forms was suggested; and where any doubt existed, I revisited the museum or collection, or in most instances was able to borrow the specimens for comparison. In the description of the species a single specimen has been described as the type, except in those referred to Bohemian forms, of which M. Barrande does not indicate which he considers as such, and the other specimens referred to the same "species" are grouped round it as best they may be. The work thus includes a description of every known *specimen* so far as it presents any available characters, or as I have discovered them. The total number of well-characterised specimens examined is about 2000, referred, as will be seen, to 143 species. This method would become too tedious to be possibly applied to the infinite number of individuals of the Jurassic forms, but it seems to me the only justifiable one with fragmentary relics such as those of the Silurian.

I have to return my sincere thanks to the various curators of the museums and owners of the collections for their kindness in allowing me to examine and borrow their treasures, of whom I must mention Sir A. Ramsay, Mr. Etheridge, Dr. Grindrod, Prof. Hughes, Dr. Woodward, Prof. Boyd Dawkins, Mr. Cocking, Prof. Geikie, and Prof. Hull, the Council of the Geological Society, and the Committee of the Cardiff Naturalists' Society, as having rendered me the greatest aid.

J. F. BLAKE.

NOTTINGHAM, *December* 1881.

BRITISH FOSSIL CEPHALOPODA.

PART I.

INTRODUCTION.

General Position of the Cephalopoda in the Animal Kingdom.

The fossil shells which form the subject of this monograph, and to which the names of *Orthoceras, Goniatites, Ammonites, Belemnites*, &c., have been applied, so closely resemble those produced by the recent *Nautilus, Spirula*, and *Sepia*, that we are completely justified in assuming that the corresponding animals presented a structure similar to the living forms—an assumption which, in some instances, has been verified by the discovery of parts of the body preserved in a fossil state. To the assemblage of these animals, including those naked or soft-bodied ones, which we know as Octopods or Polypes, Aristotle gave the name *Malakia*, and separated them from the ordinary shell-bearers, which he called *Testacea*. Cuvier, however, demonstrated a general uniformity of internal organisation throughout the several classes of the Mollusca, in which he included both of Aristotle's subdivisions, and, separating the several classes by means of their real or supposed organs of locomotion, named the objects of our present study the Cephalopoda.

The Mollusca may be very shortly defined as animals which show in the anterior or oral end of their body a bilateral symmetry, but are never divisible into segments, which are provided with a tubular alimentary canal, and whose nervous system consists of three principal pair of ganglia—the alimentary canal passing between the commissures of the first and second pair. The tegument is usually formed into a free fold called the mantle, from which may be developed branchiæ on one side and a shell on the other. In the possession of a distinct head, and of that remarkable organ in the floor of the mouth, known as the tongue, or odontophore, the Cephalopoda belong to that division of the Mollusca which was first called *Glossophora* by Lovén in 1847,[1] and at a later period *Odontophora* by Huxley; and it is with the higher classes of that division, the *Gastropoda* and *Pteropoda*, that

[1] Kongl. Vetenskaps Akad. Handlingar för är 1847.

they have the closest relations. In order to understand these relations we must suppose the animals to be placed in the same positions, the first part of the alimentary canal being taken as the axis. If this be placed horizontally, so that the odontophore is on the lower side of the mouth, we may speak of the under side of the animal as ventral and of the upper side as dorsal.

There seem to be no valid grounds for objecting to these terms, so long as they are used to represent the same parts in an invertebrate animal; nevertheless the terms "hæmal" and "neural" have been proposed as substitutes by Huxley. In the position indicated, the first, or cerebral, pair of ganglia would be on the upper, or dorsal, side; while the second, or pedal, pair would lie below, or ventrally. Hence, if we required any substitute, a less misleading one would be "cerebral" and "pedal,"[1] since the neural organs lie on both sides, and the hæmal organs on either side of the axis, indifferently. When molluscs of these several classes are placed in this way, they may all[2] be represented, at one stage or other of their development, by a body with a central tube, open at one end, and having at the other the mantle covering, which prevents the tube from opening, and deflects it either dorsally or ventrally, so that its opening is reversed. On the upper side of the alimentary tube are found the organs of sense, on the lower side, usually, the organs of locomotion; while the organs of circulation follow more or less the flexure of the intestine.

The first great distinction of the CEPHALOPODA is the rudimentary condition, or even absence, of that conspicuous organ of the lower mollusca—the foot; and the development in its place of locomotive organs of completely different character. The foot, as it is seen in all the classes that possess it, and as it is traced from its earliest commencement in the embryo, is invariably a median outgrowth from the ventral side of the body, which may or may not be divided into parts which succeed each other in a longitudinal direction. It shows little or no tendency to spread in a lateral direction, or to subdivide into symmetrical halves. It is often separated from the dorsal parts of the body by a lateral outgrowth called the *epipodium*, which is parallel to the foot and lies between it and the organs of sense. Such a median "foot" is scarcely to be recognised in any Cephalopod. Within the funnel of some, as the *Sepia* and *Nautilus*, a small tongue-shaped valve is found in a corresponding position, which alone can represent it. In the Lamellibranchs and Gastropods the foot is well developed, while it is almost rudimentary in the Pteropods, whose "wings" are formed by the epipodia.

The organs known as the "arms" have been considered by some to represent the foot; but they can only be so considered by a violent distortion of the animal from

[1] See my paper on the "Homologies of the Cephalopoda;" *Ann. and Mag. Nat. Hist.*, 1879.

[2] See Leydig, "Ueber *Paludina vivipara*," *Zeitsch. f. Wiss. Zool.*, vol. ii. Gegenbaur, 'Unters. über Pteropoden und Heteropoden.' Fol, "Sur le développement des Heteropoden," &c.; *Archives de Zool.* vol. v. Ray Lankester, "Developmental History of Mollusca," *Phil. Trans.* 1875.

its natural position, and a setting aside the guidance of adult relations and early development. These arms are, from their very origin, in pairs; so though they arise on the ventral side of the embryo, they are lateral and not median outgrowths. Moreover, they are never separated from the mouth and organs of sense by the epipodial line. They change their position with growth, and come ultimately to surround the mouth and to lie between it and the eyes. At no stage therefore of their development do they correspond in any way to the foot; but they are, on the contrary, the distinguishing organ of the Cephalopoda. Their origin may, however, be somewhat doubtfully traced in connection with other outgrowths of the embryo. They have been by many considered to represent the velum of the embryo Gastropod and Pteropod, which arises at first as a circlet of cilia, but soon develops into lateral lobes.[1] This velum so far agrees with the cephalopod arms, that it is in front of the eyes and behind the tentacles; but it never comes to surround the mouth, and it commences on the dorsal, and not on the ventral, side of the embryo. But the velum itself is but a particular modification of a more general outgrowth, to the primitive, theoretical form of which the name of "architroch"[2] has been given. This is variously modified from its original form of a circle surrounding the mouth; and, as traced through the several sub-kingdoms, is seen to be much influenced by the curvature of the intestine, to arrange itself in various ways with respect to the mouth, and to break up into halves, of which only one may be persistent. It may therefore be suggested that, as the velum of Gastropods is the dorsal half of the architroch, which does not surround the mouth, so the arms of the Cephalopod are the ventral half that does surround the mouth, and they may therefore be called an "antivelum."[3]

A second general characteristic of the Cephalopods is the partial segmentation of the ovum, the result of which is that the axis of the embryo is thrown out obliquely, and the mouth, instead of being in the centre of the anterior end, is at one side, and the anus at the other; while the mantle is central at the posterior end. This distortion rather interferes with the recognition of the true position of the several organs, and it is only after some time that, by the elevation of the embryo from the yelk, the mouth approaches its normal position.

A third peculiarity of the Cephalopoda, in which however they agree with the Pteropods, is that their intestine is bent towards the ventral, and not towards the dorsal, side of the body. The main organs of circulation have followed in the same direction, and the heart and gills are thus situated on the lower, and not on the

[1] See Grenacher, *Zeitschrift für Wiss. Zool.*, 1874, who gives an account of the various opinions held.

[2] Ray Lankester, *Quart. Journ. Micr. Sc.*, New Series, vol. xvii.

[3] Ray Lankester, loc. cit., calls the velum a "cephalotroch," and this antivelum would be a "branchiotroch," but the use of this latter term in the present case would be misleading.

upper, side of the body. In some cases the curvature of the shell has also followed, being coiled in opposite directions in a *Nautilus* and in a snail; but the *Spirula* is an exception to this rule.

These are the chief points in which the Cephalopoda, as a class, differ from the rest of the Glossophora; other distinctions which are either matters of detail, or refer to structures so peculiar that no comparison holds, will be seen from the description of the anatomy of each main type of the class, as given in the subsequent pages. From their similarity in the matter of the foot and of the flexure of the intestine, as well as in the large development of the epipodia, which become in the Pteropods the sails and in the Cephalopods the funnel, the latter are more nearly allied to the former than to the Gastropods. Whether the development of the Cephalopoda has been through the Pteropoda, or whether they both branched off from an early form of Gastropod, or even Lamellibranch, we have not, as yet, especially in the absence of all knowledge of the *Nautilus* development, sufficient data to decide. The similarity of the young Pteropod to a young Gastropod suggests the second supposition as the most probable one. Traced back to the earliest formations in which they occur, the Pteropods antedate all the other Mollusca; the Heteropods come next; the Cephalopods and Lamellibranchs are found first in the same rocks, and the Gastropods come last of all. Little importance can be attached to this order of appearance, as it is liable to be corrected at any moment, and affords no proof of the descent of one class from another; it simply adds to the balance of probability that the Cephalopods came through the Pteropods, and perhaps also through the Heteropods.

At the time of its foundation the class Cephalopoda contained but one order, in which the *Nautilus* was placed with the rest; but from the date of Professor Owen's Memoir on that animal, in the year 1832, in which he showed the important differences in its organisation, as compared with all others of the class, there has never been any doubt as to the propriety of recognising two orders—the DIBRANCHIATA for all previously known forms, and the TETRABRANCHIATA for the genus *Nautilus* alone among living animals.[1] Although the two orders are thus apparently very unequal, yet when the fossil forms are included the proportion is reversed, as the greater number of the latter belong to the second order. In point of fact, the whole of the Silurian Cephalopoda, and nearly all the rest of the Palæozoic ones, are believed to have been tetrabranchiate. With these then alone we have at present to deal, and their description will be prefaced by a detailed account of the anatomy of the *Nautilus*, as made known to us by the researches of Owen, Valenciennes, Vrolik, Macdonald, Huxley, Van der Hoeven, and Keferstein.

[1] Different names have been assigned to these orders by D'Orbigny, contrary to the rights of priority—viz., *Acetabulifera* and *Tentaculifera*—but the limits of the two orders are the same.

Anatomy of the Nautilus.

The animal of the *Nautilus* takes its shape from the last chamber of its well-known spiral shell, which in ordinary states it appears almost exactly to fill. As has been already pointed out, we must place the axis of the commencement of the alimentary canal horizontal; the portion of the animal resting against the last septum will then be posterior, the outer or convex side of the shell will lie below, or ventrally, while the upper, or dorsal, part of the body will abut against the previous whorl. (See Pl. I., fig. 1.)

The exterior covering, or mantle, is divided into two parts (fig. 1, *e*, *f*); the anterior portion is the thicker and more fibrous; it consists of two layers adhering to each other, and containing within them muscular fibres and glandular organs. These latter are, first, the nidamental glands in the female (fig. 1, *h*), to be presently described; and, secondly, numerous little crypts developed at its outer folded edge for the secretion of the outer layer of the shell. On the dorsal side, the mantle fold leaves but a shallow interval between itself and the inner mass of the body, and it is almost immediately reflected on to the convexity of the previous whorl, which it covers with a black deposit. On the ventral side, the junction of the mantle fold with the body takes place much farther back, and the former extends as a covering to the latter as far as the convex margin of the shell, whose shape it defines. There is thus left between the two a deep and wide cavity known as the mantle-cavity. The exterior surface of this ventral mantle fold is somewhat longitudinally plicated (fig. 1, *e*), but otherwise nothing has been observed to produce the " normal line " observed upon the shell in this position. The mantle fold fits over the body within by simple apposition, and covers, but is not perforated by, the funnel. The posterior portion of the mantle (fig. 1, *f*) covers the convexity of the body behind, and has the shape of the last septum. It is of greater tenuity, consisting of one membrane only, and allows the viscera to be seen through it. According to all observers, the membranous siphon is a continuation of this membrane backwards through the various chambers.[1] It is the exterior of this part of the mantle that has more especially the function of secreting the inner nacreous layer of the shell. On the dorsal side of this part are three longitudinal bands—one leading to the siphon, and one on each side parallel to it, which pass behind the siphon and join one another.

The junction of these two parts of the mantle is along a band (fig. 1, *g*) which has a sigmoid course not far from parallel to the chord of the last septum (as drawn in section), and therefore much more forward on the ventral side. Along this

[1] The relations, however, of the septa, which must be deposited by the mantle, to the siphonal covering, as observed in the shell, seem to render this doubtful, as they appear to be quite independent and to be differently secreted.

band, surrounding the whole body of the animal, the mantle, which is continuous from one side to the other, becomes very thin and closely adherent to the shell by means of a horny substance, which it secretes between itself and the shell. This horny band is known as the "annulus." Nearer the dorsal side it suddenly swells out into a kidney-shaped surface, the convexity forwards, which forms the basis of attachment of the great shell muscles.

More towards the front of the body of the animal than this ring, is another circle of membranous and muscular processes, which touches the first or the dorsal side of the shell muscles. The dorsal part of this is a semilunar fold curved forward in the centre—it lies therefore between the "hood" (to be presently described) and the dorsal fold of the mantle. On the ventral side the mantle becomes much more muscular and important, forming the two sides of the funnel. From the dorsal side of each muscle rises, on each side, the base of the funnel, most marked off in front, where it is separated from the "head" by a furrow. The sides of the funnel become longer and longer towards the ventral side, till they form two forward-directed flaps (fig. 6, *a*), one overlapping the other, sometimes the right and sometimes the left, and leaving a passage between. Thus the funnel is open on the ventral side. If the two flaps are unfolded, a valve is seen in the passage, arising from the interval between them, and directed forwards from the inside. The membrane beneath this valve is very thin, and its position is such as to prevent the re-entrance of water through the funnel. The whole of the body in front of this ring consists of the tentacular processes, with the oral aperture in the middle, the eyes and their appendages surrounding the mouth, and, exterior to all, the "hood."

The "hood" covers the dorsal part of the "head" like the "mensum" of a *Natica* (fig. 1, *a*). In shape it is conformed to the aperture of the shell (fig. 4), so that it is round in front at the free side, and excavated behind (fig. 4, *a*) in a curve parallel to the previous whorl of the shell from which it is separated by the two folds above described. It is more or less produced at the sides on the hinder part, so as to cover, in *Nautilus pompilius*, the umbilicus of the shell, which it is, perhaps erroneously, credited with obliterating, in that species, by a nacreous deposit. Interiorly it is concrescent with the "oral sheath," of which it thus comes to form a part; but it is separated at the sides by a narrow groove, and the hinder angles are thin, free lobes, unattached within. The exterior surface of the hood is wrinkled and has numerous papillæ on the sides, and in the anterior portion it is divided into two parts by a median furrow, which passes to a little notch at the free border, and has on either side an elevated line running longitudinally, by which it might be said to be divided into three (the middle third subdivided) instead of two (fig. 4). This outer surface is coloured yellow and brown, but within it is white, and has a fibrous structure: it is possibly muscular. It is thickest towards its base, or hinder part.

When the animal is retracted the anterior part of this hood is drawn backwards, so that it acts as a kind of operculum.

The "oral sheath" and its processes have different characters in the male and female, and are somewhat variable in individuals. In the female, which appears to be by far the commoner animal, we may distinguish, first the outer circle: on the dorsal side this is concrescent with the inside of the hood, which has, on each side of its middle line within, a single aperture facing forwards, from which a single tentacle may be protruded: on each side the sheath consists of a broad area which is produced in the anterior direction into a variable number (17 to 19) of irregularly arranged digitations. Each of these digitations has an aperture at the end—their exterior surface is rough or slightly canaliculate. The one nearest the hood, that is, the most dorsal one, is larger than the rest, and has its exterior formed like the hood itself, from which it looks as if it had been cut off (fig. 4, *c*). From the aperture in each of these digitations (fig. 1, *c*) may be protruded a tentacle (fig. 1, *b*). These tentacles lie free in long smooth canals excavated in the substance of the digitations and are only attached at the base. In shape they are trihedral, their inner surface is thrown into transverse deep folds, and has a longitudinal central furrow, while the outside forms the rounded angle of the triangle. In transverse section they show, rather nearer their inner side, a strong sheath of cellular tissue which protects the nerve, between which and the inner border is the vein and artery: from this sheath transverse muscular fibres arise, which diverge and seem to branch out, so as to be attached chiefly to the two outer sides, leaving the inner side more completely to nervous action: longitudinal muscular fibres run between the branches of the transverse, and by these muscles the protrusion and withdrawal is effected. The separation between the digitations is most complete dorsally; towards the ventral side they grow together, and the junction between the two sets on this side is formed by a thin membranous fold, on which the funnel rests within.

Between this outer circle and the next envelope, composed of the "labial processes," are two clusters of soft conical papillæ, and on each side a group of longitudinal lamellæ.

The labial processes, lying within the outer circle of the oral sheath, are four in number; but the circle they would form is broken, and the two dorsal ones taking their origin farther back, overlap, and thus are partly external to the ventral pair (see fig. 1, *a*). These labial processes are flattened bands with the terminations at the free ends only slightly marked off from each other, and more in single file than the digital processes. There are a variable number of tentacles in each, usually twelve or thirteen, but sometimes sixteen, and usually more on the inner than on the outer process, but the number is not always equal on the two sides. They have the same structure as the digital tentacles. The band of junction

between the external pair, which are free on the ventral side and united dorsally, is formed by two organs with a very large number of longitudinal folds, looked upon by some as rudimentary tentacles, but otherwise of unknown office. The internal pair are in like manner joined on the ventral side by a longitudinally folded band (fig. 1, *a*), which is largely supplied with nerves, and was considered by Owen to be an olfactory organ before the true seat of that sense was discovered by Valenciennes. The bands on this side are much fewer than on the other, but they are otherwise alike.

In the male the oral sheath presents some remarkable modifications from this structure. The outer circle has nearly the same characters, except that the four dorsal digital processes are more markedly separated from the rest, and lie outside and a little farther back, and there is no cluster of papillæ between the digital and the labial processes. The dorsal pair of the latter are divided on each side into two parts : the more remote and least dorsal have each eight tentacles, of which two are smaller than the other six, but the more adjacent parts are placed outside of the others; that on the right side has four tentacles of usual character, with three of the sheaths more united to each other than to the fourth, but on the left side the corresponding four tentacles are modified to form a peculiar body known as the "spadix." This is more separate than the other divisions from the rest of the labial process, so as really to stand between it and the digital processes. The spadix is a great conoidal body about two inches long; on the outer side towards the free end is a broad oval patch with a raised border, within which are a number of round apertures leading into as many small follicles set perpendicularly to the surface. A section of the spadix shows it to be composed of four tentacles, whose structure is the same, on a larger scale, as that of the rest; the innermost one of these is only united to the others by a membrane at the base; the other three are coalesced into a single mass. The dorsal junction of these labial processes shows no longitudinal folds, it is only a membrane with a reticulate surface. The ventral pair of labial processes are wanting, as such, in the male; but their place is taken by another peculiar organ. On the ventral side of the buccal mass, and in close apposition with it, is a deep fold of membrane, with a slit below, in a transverse direction : within this fold is a compound organ consisting of two nearly flat halves, each bean-shaped, and with their convexities turned towards each other. The convex margins are divided into a variable number (7 to 11) of tetragonal imperforate processes, and in addition fourteen other very thin laminæ running obliquely towards the line of junction. The office of this organ is unknown, but in form it is like a pair of retracted and rudimentary labial processes.

Within this complex oral sheath, in either sex, lies the buccal mass. This is, in the first place, covered by a fold of membrane rising from the re-entering angle of the former, and developed at its free margin into pointed and jagged processes

surrounding the jaws, and tough and membranous at the end. The inner layer of the lip is reflected over the mandibles and unites above with the outer layers; it has longitudinal internal, and circular external, muscular fibres.

The jaws are somewhat like the beak of a parrot, but not so much so as in the Dibranchiates. The upper one (fig. 3, *a*) fits into the lower (fig. 3, *b*), which surrounds it when the jaw is closed. The first has a flat surface inside, and on the outside a nearly flat surface facing outwards and forwards; the junction of the two being slightly bent inwards to a sharp point. It is divided into inner and outer (and shorter) horny laminæ, which separate in passing from the tip and are lost among the muscles. The lower beak is more convex, and bent in at its point, where it is dentated (fig. 3, *b*); it is also produced into two laminæ behind, whereof the inner one is the shortest. They are both covered near the tips by calcareous deposits, both inside and outside.

Within the jaws are found the organs of taste, the odontophore and the salivary glands. The first of these is especially formed of three prominences, succeeding each other in the median line, the lowest and most posterior of these being the larger. They are covered by long papillæ which are coated by a layer of long columnar epithelial cells. Next to these, on the way to the œsophagus, comes the odontophore. Its support is a horny, transversely striated band in the space between the sides of the lower mandible. Upon this lies, in the first place, the "radula;" consisting of about twelve transverse rows of horny and recurved teeth. Each row has thirteen teeth—the five central are trapezoidal and point towards the œsophagus; the four outer on each side are two very long and pointed, alternating with two short, flat and transverse. After the radula, the pharynx becomes papillose again both on the upper and lower sides: the cushions developed on either jaw bringing their papillæ into contact. At the sides are two glandular organs which have the apertures of their ducts at this part of the œsophagus, and which may therefore be supposed to perform the functions of salivary glands.

The œsophagus is very short, and almost immediately after passing a cartilage (to be presently described) dilates into a large pyriform crop (fig. 5, *g*), the lining membrane of which is tough and smooth, and which is provided with longitudinal and transverse muscular fibres. Macdonald describes two little glandular bodies connected with the crop by bundles of muscular fibres and by cellular tissue, but which appear to have no ducts. From the hinder end of the large crop a short tube, with rugose and villose walls, leads into the gizzard (fig. 5, *h*). The muscles of this radiate from a central point on each side, and it is lined with a furrowed chitinous membrane, but contains no gritty particles. The shells of crabs, &c., which form the animal's food, must be broken by mutual attrition. The pyloric aperture, which is protected by a valve, takes its rise very near to, but below, the entrance of the œsophagus. The alimentary canal is, therefore, said by Huxley to have a neural

flexure, as the pedal ganglia lie between the two directions of its parts. As, however, the heart lies on the same side of the body as the pedal ganglia, as it does in many other molluscs, the terms neural and hæmal would appear to be misnomers. Here the intestine turns towards the heart and the other main portions of the circulating system.

At the commencement of the intestine is the opening of a globular receptacle (fig. 5, *i*) which is filled with broad parallel laminæ, transversely ridged, and which may itself be glandular. One of the laminæ, longer than the others, prevents the regurgitation of the secretion into the gizzard. On the opposite side to that on which it opens into the intestine this receptacle communicates with the main duct of the liver. This is a large organ lying at the sides of the crop. It is roughly divisible into four lobes, with perhaps a fifth between them; but it consists of numerous, scarcely united, lobules of angular form, covered by delicate layers of peritoneum. Each lobule consists of acini suspended either to the blood-vessels or ducts, the latter of which gradually unite before entering the receptacle at the entrance to the intestine. This receptacle Prof. Owen thinks may also serve the functions of a pancreas. From it the intestine continues its course forwards, then makes a backward fold, the two sides of which are united by a mesentery, and then it passes forwards to the anus, which lies ventrally in the median line of the mantle cavity, and opposite the bases of the lower branchiæ, where it has swollen lips (fig. 6, *b*).

The cartilage which surrounds the œsophagus, supports the nervous ganglia, and gives origin to several muscles, has a very peculiar form (fig. 7). Its under-surface is tolerably flat in its general aspect; it is widest in its rounded central part or body, from whence a process or horn projects on each side, running forwards and downwards into the base of the funnel. From the opposite side are also two processes, which, however, instead of being straight like the others, curve out so as to leave a circular opening between them, which forms a passage for the œsophagus. The inner and under side of these, together with the body, are excavated in an irregular circular groove, to support the ganglia on whose shape they are moulded. On the upper side the body is produced into a prominence, whose flat, heart-shaped surface faces upwards and backwards, the apex being away from the body of the cartilage; the horns have processes imbedded in the sides of the funnel.

The principal muscles are—first, the shell-muscles. These are strong masses which are attached at one end to the two halves of the heart-shaped cartilage-face just described, pass obliquely backwards and outwards, to be attached to the large patches where the mantle has made a horny deposit on the sides of the shell. There seems to be some little doubt as to the amount of attachment that exists between the muscle, the horny band, and the shell; but Macdonald, the only writer who has seen the animal in its fresh state, observes that the fasciculi of the muscles do not penetrate the mantle nor become attached to the shell, and shows admirably how the contrac-

tion of these oblique muscles, by enlarging the angle between them, enables the shell to act as a fulcrum without attachment. This would tally well with the absence of any impressed muscle-marks in either the recent or fossil shells, and with the exigencies of the animal in his periodical moves. The next set of muscles are those of the funnel: the main ones commence in the sides, at the junction of the mantle and the hood, and increase by additional fibres coming from the dorsal processes and the sides of the cartilage. They consist of an inner transverse set, which pass across the shell-muscles, and an outer set, which become more longitudinal by passing into the folds of the funnel. Another pair arise from the ventral horns of the cartilage, and pass in smooth canals to the tip of the funnel, which they draw away from the valve which lies within it. By the action of these muscles it is easily seen how water can be driven out of the mantle cavity by the funnel itself, without the motion of other parts of the body—a motion which would be inconvenient to an animal fixed to a shell. The third important set of muscles are those connected with the mouth, which arise from the under-surface of the cartilage: one pair of retractors take their origin at the upper ends of the circumœsophageal processes, and pass within the plates of the smaller mandible: another pair surround the cartilage outside the nervous collar, and pass partly into the labial processes, and partly into the lower mandible and to its odontophore. The protrusor is a muscle which passes from the base of one posterior labial process and round the smaller mandible on its upper side, thus acting at the same time as a depressor.

The circulating system of the *Nautilus* has been found more difficult of elucidation, but at the same time perhaps more interesting, than any other part of its organisation. The heart is situated on the ventral side of the body, just above the mantle cavity, and a little to the left. It consists of one chamber only, of quadrate form (fig. 2, *i*), twice as broad as long, and which receives the branchial veins (fig. 2, *h*) at the four corners, each entrance being guarded by a semilunar valve. It is traversed within by fleshy columns, and gives origin to a less and a greater aorta. The first arises from the under side near the centre, where its orifice is guarded by two valves. It is ultimately divided into three branches; one passing to the nidamental gland in the female, a second to the intestinal mesentery, and the third turns back to pass through an aperture in the fold of peritonæum which has been called the pericardium, to supply the siphon (fig. 2, *k*). The second or great aorta (fig. 2, *l*) rises from the left hind corner, and has muscular parietes at first, like an aortic bulb, beyond which it is guarded by a valve; it first supplies the gizzard and the generative organs, between which it passes backwards, it then turns forwards again, sends a branch to the liver, runs along the dorsal side of the crop, supplies the shell-muscles, and, finally, is distributed to the parts about the mouth and the funnel. Besides these, in close connection with the heart, is an elongated pyriform sac, which is closed nearest the heart, and, according to Prof. Owen, at

the other end too; but Keferstein represents it as opening into the mantle cavity. It has a folded interior, but no office is assigned to it, though Prof. Owen suggests it may be an aborted tube of communication between the venous and arterial system. The ultimate distribution of the blood cannot be traced in the *Nautilus*. On the one hand, if it be true, as Koffman asserts,[1] that in other Cephalopoda its ultimate destination is into sinuses with definite walls, and not into general lacunæ between the viscera (and we remember that there is communication between the pericardium and the exterior in the *Nautilus*), it would appear very unlikely that blood and water should be thus mixed, but more probable that it should be retained within walls: on the other hand, the peculiar structure of the vena cava would appear useless in that case (fig. 2, *a*, *b*). The blood from the lower parts of the animal is collected into a large sinus which is excavated in the body of the cartilage and in its two lower horns; from thence it passes backwards by a large vena cava, which lies on the ventral side of the body, or upper side of the mantle cavity, between the two shell-muscles, though it does not expand as the latter separate; it is bounded below by the membrane of the mantle cavity, but within it has transverse muscular fibres lying upon it, which leave small apertures between them, by which its interior is in communication with the visceral cavity: thus blood in that cavity, or sea-water which might gain admission there, may equally well be introduced into the circulation. When this vena cava has passed into the neighbourhood of the heart, other veins from the viscera, including one from the liver, join it, and form a venous sinus (fig. 2, *c*). From the sides of this sinus a vein arises on each side; this quickly divides into two, which become the afferent veins of the two branchiæ (fig. 2, *d*). There are no expansions of these veins, but some peculiar glandular follicles lie upon them, and on the remoter sides (fig. 2, *e*) are closed sacs, while between them lies a space which is part of the general visceral cavity, *i.e.* the pericardial portion of it. Into each of the closed sacs (fig. 6, d°, d', d'') there is an aperture from the mantle cavity (fig. 6, *e*). The lower one opens on a little tubercle near the base of the lower branchia, and the upper by a narrow slit near the base of the other branchia. Close to this last aperture, and nearer to the middle line, is a third, larger, one leading into the pericardial space, which it thus puts in communication with the exterior. Valenciennes describes this as having an overhanging and so valvular edge, so that it should serve for exit only. Between the bases of the two branchiæ there is also a small tubercle of unknown use. In the two "excretion sacs" are a number of follicles collected into two flattened plates by a superficial membrane, which as a whole have a kidney-shaped appearance. The sacs are open at the distal end, and also (according to Owen) at the junction with the vein (but, according to Keferstein, they are closed). The inside of the sac is filled with concentric concretions of phosphate of lime, amongst which the follicles lie imbedded, but there is no uric acid.

[1] *Zeitschrift für Wiss. Zool.* vol. xxvi. p. 87.

The glandular masses which open on the opposite side of the vein and hang into the pericardial cavity consist each of a single tuft, which is larger than all the mass in the excretion sacs. They are covered by a fatty substance, and have an exterior layer of nucleated cells. Macdonald has minutely described the structure of one or other of these follicles, but he did not distinguish between those in the sacs and those in the pericardial cavity. The interior of those described by him is thrown into folds radiating from the proximal end, and set with papillæ, appearing like a circular fan or folded filtering paper, forming an efferent valve. The function of these appendages seems doubtful. From their position they might be thought renal, yet they contain no uric acid. They may, however, be excretory in some way, and the laminated ones may have a different function from the others. Prof. Owen has suggested that they might act as reservoirs to relieve the pressure of the blood during the animal's ascent to the surface. From the neighbourhood of these follicles each afferent vein, after the junction of another from the shell-muscle of its side, reaches the base of its own branchia, the entrance to which is narrow and valvular.

The branchiæ are four—two on each side—the anterior ones are smaller and nearer to the median line; each stands on its own separate pedicle, and lies free in the branchial chamber, or mantle cavity. The larger branchia (fig. 6, *c*) is composed of between forty and fifty transverse laminæ, which are divided and subdivided into filaments which collect again to lead to the efferent vein on the opposite side, and so appear to be arranged alternately; the efferent vein expands before leaving the branchia and has orifices all along it (fig. 2, *f*). The efferent veins lie free from the peritoneal investment and reach the heart without change. The smaller branchia has about three-fourths as many laminæ as the larger.

There are folds of peritoneum crossing the visceral cavity from back to front which more or less separate the posterior part with the heart from the venus sinus, and several other organs, but leaving wide apertures by which one compartment communicates with the other. Through the middle one of these passes the siphon with its artery, which is thus put in communication with the exterior through the pericardium.

The central nervous system is partly protected in the cartilaginous groove surrounding the œsophagus already described, and partly supported by a tough membrane. It consists dorsally of a thick transverse commissure between the great sense ganglia, and ventrally by two thick cords, joining the dorsal part at the same points; one of these is in front and slightly concave forwards, the other behind and deeply concave forwards. From these three cords eleven sets of nerves take their origin. From the front border of the first come off (1) the ocular, from near the junction with the other cords; (2) the nasal, just beyond; (3) the aural, from within the other two; (4) super-oculo-tentacular, from an origin nearer the middle line and the sub-oculo-tentacular from behind. From the hinder border

(5) the lingual and (6) the oral. From the front border of the front ventral cord (7) the tentacular and (8) the labial; and from the hinder border of the hinder ventral cord (10) the motor and (11) the visceral. The tentacular nerves are numerous, as each tentacle has its own independent nerve. So, too, the labial: the nerves to each tentacle of the external labial processes are distinct, but the inner labial process of the female has a single nerve which subdivides only, after having formed a ganglion. The nerves to the funnel (9) rise nearer the middle line: the motor nerves pass without forming any ganglia direct into the great shell-muscles: the visceral nerves rise near the middle line, pass up on each side of the vena cava, give off a twig to the branchiæ and form a ganglion, which may perhaps be called the "ganglion stellatum."

The eye stands out on a pedicle which projects from the body, in front of the sides of the funnel, near the dorsal side; the hood in front rises up to cover one half of the eye, and the mantle behind nearly covers the other half, leaving a small interval, when either is slightly withdrawn, through which the pupil peeps. In shape the eye is like a triangular pyramid, rapidly enlarging at the distal end; the surface is flat, coloured, and rather warty; it is provided on the front and ventral two-thirds with a free fold, from which another fold is continued to the minute aperture, which is less than one-eighth the diameter of the eye. The interior of the eye is one of the most remarkable in nature, from the absence of almost all the structures which usually characterise that organ. The nerve, arising from near the end of the upper commissure, expands after entering the pedicle into a large mass at the base of the eye, where it divides and subdivides to form the sentient layer. Externally the eye has a strong fibrous coat—the sclerotic; within this is a yellow layer of cellular tissue; on the concave surface of this the nerves are spread out to form the retina, which is overlaid by a layer of black pigment. The nerves, however, pass into this layer to the ends of a number of rod-like cells which stand vertically upon and in the pigment layer. These structures form the internal lining of the cavity of the eye, in which there is nothing more. The pupil therefore must simply act like a pinhole in a card, to produce an image of the exterior objects upon the retina behind.[1]

On either side of the eye, in front and behind, is a tentacle distinct from those already described, and obviously in connection with the organ of vision. These have a similar structure to the others—except that they are more incised, and so consist of a number of plates connected by a subcentral stem. They are supplied by nerves directly from the commissure, and are probably altogether sentient in function.

[1] The histology of the eye of the *Nautilus* is admirably figured and described by Hensen, *Zeitschrift für Wiss. Zool.* vol. xv. 1865. See also Keferstein in Bronn's 'Classen und Ordnungen,' Band iii.

The organ of smell is in close connection with the eye. It rises like another tentacular sheath from behind the eye; but its orifice, instead of being round, is slightly expanded at the sides and covered by a tubercle arising from the proximal side, so that its aperture is oblique and complex. This leads into a hollow cavity, whose interior is thrown into folds like the barbules of a feather: it is supplied by a large nerve direct from the upper commissure: its form and its homologous position to similar organs in the Dibranchiates have left no doubt of its function, though it was looked upon by Macdonald as representing an external ear.

The organ of hearing is, in fact, seated immediately beneath it, as was discovered by Macdonald. It is situated at the junction of the two commissures, whence its nerve is derived, and consists of a little convex capsule resting in a depression excavated in the cartilage. Its contents are minute bodies of calcareous nature—"otoconia," of fusiform shape, floating freely in the cavity, or uniting together in pairs.

The reproductive organs of the female consist of the following parts. The ovary lies in the hinder part of the body; and in its undistended state, in which alone it seems to have been hitherto found, is confined to the left side of the gizzard, which it slightly overlaps below. It is contained in a fold of the peritoneum, and opens with a puckered margin into the visceral cavity at its anterior end. It is thus not continuous with the oviduct, but the apertures of the two face each other. Within the ovary are found a number of pyriform capsules, opening inwards, and attached at their blind ends to the inner surface of the sac—they are most crowded together near the entrance of the nutrient vessels. The oviduct leads down by the side of the intestine to a prominent and ridged aperture which lies on the right side of the animal near the base of the funnel. Connected with the female generative organs is a large gland, imbedded between the coats of the mantle on its ventral side, some little way in front of the horny annulus. It thus lies in close apposition to the convex part of the shell. Internally it consists of three parts; on each side there is a large oval mass, which makes a prominent feature on the surface of the mantle (fig. 1, *h*) when the animal is removed from its shell; and connecting these is a transverse portion. They all consist of a number of parallel laminæ (fig. 6, *f*), which run transversely in the central portion and obliquely in the other parts. These are made of perpendicularly set nucleated cells which secrete albumen. The apertures from this gland are a number of minute openings in a groove formed by a transverse fold of membrane, which rises into a pair of small prominences near the middle line. The secretion is thus brought into proximity with the oviducal aperture; and as it affords, in all probability, a covering for the eggs, the gland must be a nidamental gland.

The male organs of generation, as described by Van der Hoeven and Keferstein, are as follows:—In the same position as the ovary in the female, lies a large testis.

It is of a flattened oval form, with the long axis longitudinal. At the time of its examination by Van der Hoeven there were spermatophores in the course of development and extrusion; and at that time it was the second largest viscus in the body, but it did not encroach particularly on the hinder part of the visceral cavity. It is enclosed in a fold of membrane, and consists of nine or ten more or less conspicuous lobes, made of a number of acini of a brownish-yellow colour, with their distal ends blind and their proximal ends attached to the branches of the efferent vessel into which they open. This efferent vessel passes forwards to near the right-hand corner of the testis, where it has a prominent papillary aperture. Immediately opposite to this is a groove in another smaller gland lying in front, and to the right into which the prominence loosely fits. At the base of this groove is a slit which leads into a larger cavity, from which passes a fine duct leading into a wider tube, which makes a few convolutions in the smaller gland and ends in sac at the anterior left-hand side. In this course the gland, which consists of many lobules of blind tubules, supplies an additional secretion. From the last-mentioned sac, which is contained within the gland, passes a thick-walled tube into the spermatophore sac, or "Needham's pouch," lying to the right of the median line of the body. This is a cylindrical bladder with very firm walls and longitudinal folds within. It has an oblique longitudinal partition, which opens in front and gives exit into the base of the penis. This latter organ is obtusely conical and lies in the mid line about halfway along the course of the shell-muscles. It is concrescent with the body on the inner side, and has a transverse slit at its extremity with swollen margins. In the spermatophore sacs are seen numerous convoluted spermatophores, which do not attain perfection till reaching this cavity. They have no covering here; but some are always found between the smaller tentacles of the labial processes, in which position they are each encased in a structureless cover, which they could not have had when passing through the narrow penial canal. There is no nidamental gland in the male, but these enclosed spermatophores are found in close proximity to the glandular part of the spadix from which they may well have received their covering. In this case the process which forms this spadix may be looked upon as a hectocotylised arm. Each spermatophore is a convoluted tube, about ten or twelve inches long and half a line in diameter, with a twisted and retroverted end, and contains within it a spiral thread (as in the trachea of an insect), to which the spermatozoa are attached by their thin extremities.

Such are the known features of the organisation of the *Nautilus*. Unfortunately at the present day we are in total ignorance as to its development.

It would occupy too much space and not be to our immediate purpose to enter into similar details with respect to the organisation of the Dibranchiates, which will come more appropriately as introductions to those parts which treat specially of their British fossil representatives. When the two orders are compared, it will be

found that in many points the *Tetrabranchiata* represent an early stage of the *Dibranchiata,* as, for example, in the structure of the eye, the position of the auditory organ, and the disposition of the tentacles. This fact is of great interest in connection with their geological distribution, for that order which is most embryonic in structure is also earliest in time; for we cannot suppose that, with all the imperfection of the geological record, Belemnites could have existed during the Silurian period and not have left a single indication in the rocks.

The structure of the shell and of the organs immediately connected with it is so essentially connected with the interpretation of fossil forms, which, in their turn, throw light upon the recent one, that it is necessary to consider it separately.

The Shells of the Nautiloids and their Terminology.

As the description of the soft parts has been restricted to that of the single representative of the Tetrabranchiates, so must the features of the shell be only here noticed so far as they are found in the Nautiloidea, which alone occur in Silurian deposits, and the characters of the Ammonitoidean shells will be reserved till their British fossil representatives come to be described.

In relation to the shell, we have to consider :—1. The internal structure. 2. The external form. 3. The commencement. 4. The body-chamber. 5. The aperture. 6. The ornaments. 7. The septa. 8. The siphuncle. 9. The internal marks.

1. *The Internal Structure.*

The structure of the shell of the recent *Nautilus pompilius* has been described by Dr. Carpenter in the 'Report of the British Association for 1847,' and figures have more recently been given by Hyatt.[1] In the external shell two distinct layers have generally been recognised (Pl. II., fig. 1, *a*, *b*), and Hyatt describes also a third or lining layer, which will be noticed presently. Of the first two, the outer one is usually called the porcellanous layer, because it is opaque. As seen in a thin section parallel to the surface, it presents a speckled appearance, which, on raising the magnifying power, is seen to be due to a number of transparent crystalline particles, set in a dark and opaque ground (see Pl. II., fig. 6); these particles have irregular outlines, and the crystalline structure shows a radiating arrangement. They are so closely aggregated as to leave the darker substance as lines only with occasional spaces. The size of the particles is largest towards the inside where the two layers unite, and their radiating structure is there more distinctly seen. The colours of the shell are produced in this layer, and they do not arise from the increase of the intermediate substance, but are due to the coloration of the crystalline particles

[1] "Fossil Cephalopods of the Museum of Comparative Zoology—Embryology."—*Bull. of Mus. Comp. Zool.*, vol. iii. No. 5, 1875.

(fig. 6, *a*). There are, however, darker bands in the internal substance, due to the greater scarcity of these particles. The external surface of the shell, which has a number of lines of growth parallel to the curvature of the aperture, shows that this layer is gradually deposited by the edge of the mantle. This mantle edge must also be crinkled, for there are an infinitude of spiral lines imbricating in different directions, themselves thrown into crinkles by the lines of growth. On the approach of this layer to the inner one, where the crystalline particles are largest, it is lined on the inner side by a fine network of dark lines, without any regularity, and this is the only separation between the two layers. The inner layer is nacreous to the external view. In a section from the outside to the inside are seen a number of nearly horizontal parallel lines (see Pl. II., fig. 1, *a*), more marked in some places than in others, and irregularly spaced: these are not parallel to the inner or outer surface of the layer, but pass towards the outside of the shell, as we trace them forward, and thus indicate that the nacreous layer has been formed, not at the edge of the shell, but by the surface of the mantle, as a series of deposits lying on each other obliquely to the surface of the shell. This is described by Hyatt as imbricated structure; it is not only seen on the large scale, where a few of the layers being discoloured render it more conspicuous, but is of the essence of the formation of the layer. For under the microscope each part of the layer is seen to be composed of successive plates from $\frac{1}{20000}$ to $\frac{1}{30000}$ of an inch in thickness (see Pl. II., fig. 7). As these crop out in the interior of the shell, or on a polished surface, they produce a number of parallel lines, which, causing interference of the rays of light falling on them, give the appearance of nacre or mother-of-pearl. This is not well seen in the later part of the shell, because the surface is there covered by a thin lining layer, or by the prolongation of a septum, but the blue and red iridescent colours may be seen in the first two or three chambers, and the ends of the fine plates seen cropping out under a low power (see Pl. II., fig. 5). Dr. Carpenter[1] has expressed the opinion that nacre is due to the folding of a membrane, and not to a succession of deposits. Both, however, in the case of *Haliotis splendens* to which he refers, and in that of the *Nautilus*, the nacreous appearance is certainly caused by these simple superposed laminæ, whose whole course may be traced in a vertical section. In a horizontal section they produce a number of slightly curved parallel lines,[2] which are closer or farther apart, according as the section cuts the laminæ vertically or obliquely. In places they are thrown out of their direct course (see Pl. II., fig. 7, *a*), to make an acute angle, all the apices of the angles lying on a straight line, just as though the successive laminæ had to pass over some narrow obstacle; these lines

[1] 'The Microscope and its Revelations,' 1862, p. 607.

[2] These curved lines make a thin and perfectly flat section *look* concave on the side that was so in the shell and convex on the other, just as the undulating lines on a *Haliotis* makes its section look crinkled.

of disturbance are not parallel. The vertical section of the nacreous layer shows, besides the parallel lines of deposit, a number of other lines perpendicular to them, and appearing to divide the layer into a number of narrow prisms (Pl. II., fig. 1, *h*). A horizontal section explains the cause (see Pl. II., fig. 8). A number of small irregularly shaped dark spots are seen scattered over the surface, which correspond to intervals crossing the laminæ, filled with some dark substance. In the outer part of the shell they are very small (fig. 7), but in the inside and on the septa they are better displayed (fig. 8).

These same two layers, which make up the bulk of the external shell, may be seen also in a modified form in the inner side, where the whorl rests on the outside of the previous one (Pl. II., fig. 1, *d*, *e*). Here the outer layer amalgamates with the black layer supposed to be deposited by the hood (fig. 1, *c*): though the characters of the two are perfectly distinct, one being transparent and crystalline, and the other dark, opaque, and amorphous, there is no proper line of junction, but the outer part of the black layer is perfectly honeycombed by the scattered and connected crystalline particles. These differ from those of the outside of the shell in being closer, and so leaving no dark intervals, except when in the black layer. The interior or nacreous layer differs in having the laminæ closer together (fig. 1, *e*). I have counted 980 of them in the thickness of about one-sixtieth of an inch. At the same time the dark spaces are much larger; they are seen to be irregular in position in this part, and not so directly transverse; they send out fine ramifying lines, like those of the lacunæ of a bone, only shorter (fig. 8), and their function may be formative, but is not nutritive. Thus the inner and outer layer may be formed by a modification of the same process; in both secretion takes place at various spots; in the outer layer the crystalline particles remain distinct, but in the inner layer they amalgamate into laminæ, and leave only ramifying lacunæ to represent their interspaces. The outlines of the laminæ are not absolutely regular, but occasionally aggregate towards a lacuna, or one is lost there. Besides these two layers there is a third, lining the interior of the shell. This is of very small thickness, and consists of similar laminæ to the nacreous layer (fig. 1, *f*), and its existence may often therefore be overlooked or doubted, but it may be seen lying between the septum and the inner layer of the shell, with its laminæ running in a different direction. They are not, however, so parallel in their outlines, but are thrown into irregular folds by very numerous lines of disturbance. In the acute angles made by the junction of the septa with the circumference of the shell is another deposit (fig. 1, *g*), less transparent than the nacreous layer, but showing very little structure. As this is not moulded on the surface of the mantle, but merely fills the space between contiguous parts, it may be looked on as possibly the result of an excretion which takes up its actual place by "capillary attraction."

The septa consist of one main layer only, which is formed in exactly the same

manner as the inner layer of the shell (fig. 1, *h*). In the closeness of the laminæ and in the size of the dark lacunæ, it is intermediate between the corresponding layers of the convex and concave part of the shell; but the laminæ, instead of being oblique, are parallel to the surface of the septum. Hence the septum is not nacreous in the usual sense, there are no outcropping edges on its surface; but the opaque lacunæ are seen, as it were, floating in a transparent medium when it is viewed as an opaque object. The peculiar lustre of a septal surface is not indeed like that of nacre, but more like that of a true pearl. The actual surface is corrugated by a very minute network of straight lines, running between the ends of the lacunæ; but they are very difficult to see, and the lustre may be due rather to the reflection from the opaque lacunæ—especially as it may be very closely imitated by artificial pearls—in which there are also opaque particles floating in a transparent ground-mass. On reaching the siphuncle the laminæ curve round into the neck, but only the earliest half of the series reaches the apex. In this neighbourhood the lacunæ are more numerous and larger. Each septum is lined on either side by a loose amorphous deposit, of which the one on the convex side is the thicker, and is of sufficient tenacity to have the appearance, when cracked, of a torn membrane; it passes at the sides of the shell into the deposit lining the concavity of the last preceding septum.

The essential feature in this structure of the shell, so far as it may be applied to the study of fossil forms, is that the external layer is indivisible, while the internal layer is divisible into an infinity of laminæ, which are oblique in the shell but parallel to the surface in the septa, and which show a tendency to split more freely along certain lines; the inner layer being also distinguished from the outer by the presence of lacunæ and the absence of radiate crystallisation.

That the shells of the *Orthocerata* and other Nautiloids were in like manner composed of two layers is easy of demonstration in a well-preserved shell—such as *Orthoceras annulatum* of the Silurian, or *O. attenuatum* of the Carboniferous; but further than this there is but little certainty. The whole of the shells that have passed under my examination have suffered so much mineral crystallisation, that their original structure is nearly if not entirely obliterated. In the outer layer the crystalline parts are clear and better defined, and no subdivisions are seen. In the inner layer, on the contrary, the crystals are all spotted, as if by the remains of such vacuities as the lacunæ, and the thickness is subdivided by cracks nearly parallel to the boundary between the two layers, which doubtless correspond to the easy lines of division in the *Nautilus;* but I have not been able to demonstrate the laminæ. The septa have a structure similar to that of the inner layer.

It is very common to meet with specimens whose surface has been "skinned," that is, the outer layers of the shell have peeled off; sometimes the ornaments of the

exterior are repeated on the surface exposed in a more feeble manner, sometimes a different set of structural markings appear. Since the exterior layer is a single one—and from its mode of formation must be so—these lower surfaces must in all cases belong to the inner or nacreous layer, and there is never any evidence to show that the outer layer is double.

Some of the shells of the *Orthocerata*, as such *O. primævum*, seem to have been very thin; while others, such as *O. annulatum*, are of considerable thickness. When the surface shows marks of coloration, we may be sure of the presence of the outer layer; but in the case of the thin shells there is no proof of its preservation. Cases are often met with in which the shell has been broken and repaired during life—and this may be seen also in recent *Nautilus* shells—the outer layer taking part in the repairs; but this does not prove that it had more than one layer.

2. *The External Form.*

The essential form of the Nautiloidean shells is that of a cone, that is, a solid produced by the motion of a curve which remains similar to itself, but uniformly enlarging in size as its centre, or some fixed point in it, moves along another curve. The different forms will therefore arise, first, from the shape of the curve of section; secondly, from the rate of its increase; and thirdly, from the shape of the curve on which the fixed point moves. The effect of these may be considered separately.

(*a.*) *The form of section.*—The particular shape will depend on the direction in which the section is taken, and it is therefore always supposed to be taken in a plane perpendicular to the curve of motion. When the shell is involute, as in the *Nautilus*, the actual section is only part of the whole curve which would be formed geometrically by the same law; as, for example, the section of the recent *Nautilus* is half an ellipse. The most common form of section as regards species is the circular, the greater number belonging to the genus *Orthoceras.* The next common is the elliptic; the long axis of which may either lie in the plane of symmetry, when the section is said to be direct, or perpendicular to it, when the section is said to be transverse. The next most common form is the oval, derived from the directly elliptic by one end being broader than the other; the broad end may lie either towards the outside or towards the inside. Other less frequent forms are the triangular, chiefly met with among open whorled forms; the subquadrate, mostly belonging to involute shells; and the polygonal or irregular, due to the importance of longitudinal ornaments. It seems to me to be entirely a matter of individual fancy whether the more remarkable of these forms should be allowed to have a generic value, that is, whether such names as *Gonioceras* or *Trigonoceras* should be employed. The shape of the section, though normally remaining similar, does not always do so, but frequently changes in the neighbourhood of the aperture of adults—the circular

becoming elliptic, and *vice versâ*, or the subquadrate becoming more rounded. These peculiarities, combined with others, give rise to such genera as *Phragmoceras*.

(*b*.) *The law of variation.*—The section usually increases in size at a uniform rate from near the apex to the aperture. In the case of straight or slightly curved shells this rate may be expressed either by the vertical angle of the cone, or by the difference of two corresponding diameters of the section divided by the distance between them.[1] Thus, if two given diameters at a distance of 2 inches are 13 lines and 10 lines respectively, the rate of increase is 3 in 24 or 1 in 8. If the section be circular, any diameter will give the same rate of increase; but if it be elliptic, we must specify which diameter is taken, since it is obvious that the longer diameter will increase more rapidly than the smaller on the same shell. When the shape of section is known, either will give the true form of the shell. When there is any curvature, the increase of the transverse diameter is the most convenient to measure, the distance between the sections being taken along the curved line. When the shell is a coiled one, the ratio of the breadth of the last whorl to the whole diameter, which involves but does not depend wholly upon the rate of increase, may be conveniently taken to represent it.[2] It is worth noticing that the ratio of the breadth of a whorl at one end of a diameter to that at the opposite end of the same diameter does not depend upon the rate of increase at all, but only on the curvature of the spiral.

The rate of increase thus measured can only have reference to the general form, for it is seldom entirely constant. The tip of the shell is always, so to speak, rounded off, so that the increase is rapid at first, and only settles down later on to its typical amount. On the other hand, the greater part of all the changes taking place in the body-chambers of the adults is due to the variations of this element, such as the contraction towards the aperture in the *Phragmocerata*. Indeed, scarcely any shell retains the same rate of increase throughout, but it generally diminishes, or more rarely increases, at last. In specimens agreeing in all other respects we also find that some have a greater and some a less rate of increase—and a certain range of variation must be allowed, especially as some of the difference may be due to compression. Nevertheless, this element forms one of the most important criteria of species, for in some of the smooth *Orthocerata* it becomes almost the only thing left to judge by. The general amount of the rate of increase has also been made use of to group the species of various genera. Thus, among the uncoiled forms, Barrande has distinguished those in which it is great as *brevicones*,

[1] In the descriptions given by Barrande the *ratio* of the two diameters is given, which is of no value, since on the same cone the ratio of two diameters at a given distance varies with their position; and the same ratio may be found on *different* cones if taken at suitable positions.

[2] For the mathematics of these curves see my paper in the *Phil. Mag.* 1878, "On the Measurement of the Curves formed by Cephalopods and other Molluscs."

and those in which it is small as *longicones;* whilst among coiled forms many attempts have been made to separate those that are involute, or have a rapid rate of increase, from those that are more uncovered.

(*c.*) *The curve of motion.*—This is usually assumed to be an equiangular spiral, in which the straight line may be included as an extreme case. On this assumption, I have indicated, in the paper above referred to, how the spiral of any particular shell can be ascertained from fragments. In practice, however, only a rough approximation can be arrived at among the Palæozoic Nautilidæ; for, partly owing to irregularities of contour, partly to the unknown amount of imbedding in the rock, and partly to a natural variation in specimens of the same species, no measures on ill-preserved shells are sufficiently reliable for calculation. To account for the deviations from the true equiangular spiral in recent shells, Professor Naumann [1] supposed the curve of motion to be one, allied only to the equiangular spiral, which he called the "conchospiral." This may be a perfectly true supposition, but the curve is less manageable, and the equiangular spiral is quite a close enough approximation when we are dealing with fossil shells which cannot be observed with minute accuracy. In the case of coiled shells in which more than half a whorl is preserved, the ratio of two diameters of the whorls, that is, the breadth of the last whorl divided by that of the whorl at the opposite end of the same diameter, gives us the element of the curve as compared with another of the same kind, whether it be an equiangular or a concho-spiral. This, therefore, is one of the essential elements of the form of the species. When the shell is open, so that it has no diameter, an analogous method is inconvenient, and the curvature is sufficiently defined by the ratio of the mean radius of curvature to the mean breadth of the whorl. The curvature of course, by the nature of the curve, decreases with the growth; but, as in the case supposed, only a small portion of a whorl exists; the circle which has the same curvature as the middle portion seldom deviates much from the general outline. But earlier parts of the same shell having a greater curvature than the later, the absolute radius is not sufficient, but its ratio to the corresponding breadth must be given, which is the same for all parts of the same shell.

Besides the minor variations that this element shows, there are, in the case of the *Lituites* and others, those sudden cessations of curvature which produce the long, straight body chamber. Also in *Trochoceras,* the spiral is not in a plane, but forms a helico-spiral. In this case we may state, as a fourth element of the shape, the elevation in the height of the apex above the median plane of the base, divided by the diameter of the base. In the Silurian species, however, this is seldom necessary, as it requires a careful examination to ascertain that there is any want of symmetry at all.

On the direction of the curvature.—Seeing that it is known that the curvature of

* 'Die Cyclocentrische Conchospiral.'

the *Gastropods* and *Spirula* takes place in one direction, so that the dorsal is the convex side, and that of the *Nautilus* in the opposite, the dorsal being the concave side, we may be prepared to find in the less settled Palæozoic forms variations in this respect in more closely allied groups. For these two directions the terms "endogastric" and "exogastric" were proposed by Sæmann in 1852,[1] the former for those in which the ventral side of the animal was on the concave side of the shell, and the latter for such shells as the *Nautilus*. It is not easy to determine which was the ventral side in these fossil shells. Since in the recent *Nautilus* the exterior has a backward sinus which is indicated by the parallel lines of growth, it is assumed that such a sinus in the ornaments of a fossil indicates its ventral side. Cases, however, are not wanting in which a sinus occurs on both sides of the shell, as in the *Phragmocerata*; hence we have no grounds for assuming in coiled shells that the true sinus for the ventral side was not internal. It is also assumed, and no doubt truly, that the small aperture of *Gomphocerata*, &c., indicates the ventral side; but whether this be so or not, it must always indicate the *same* side of the animal; and this affords conclusive proof that in this group, at least, there was sometimes a curvature in one direction and sometimes in the other; for in *Phragmoceras* this aperture is more usually, but not constantly, on the more concave side, while in *Gomphoceras* it is more commonly on the convex side.

3. *The Commencement.*

When the shell of a Nautiloid is traced towards its smaller end, a point is reached at which it ceases to have the conical shape of its adult age, and the apex of the cone is replaced by a cap of some other shape. This cap, besides its shape, often shows other peculiarities which distinguish it from the rest of the shell. The importance of the study of this part is obvious from its connection with the development of the Nautiloid. We may here learn those characters which point to the origin of the forms possessing them, and any fundamental distinction found will prove a bifurcation of the group. In point of fact the Nautiloidea and Ammonitoidea are as much separated by the characters of this part as they are by those of the adult. So important from a theoretical point of view has M. Barrande considered this, that of all his large work containing general observations on Cephalopods he has selected the part containing his observations on it to be separately printed and distributed, as his most potent proof of the falsity of the doctrine of Evolution. In the Ammonitoidea, as far as yet ascertained by accurate observations, the cap is always inflated and more or less globular in form, and has a smooth exterior. From one side of it the shell starts at once in its regular conical form. This is the case even with those Goniatites of the Silurian rocks, in which the commencement has been observed.

No such inflated cap is to be found in any of the Nautiloidea, so that in this

[1] 'Palæontographica.'

feature, as well as in others, the two suborders were as sharply defined when first found together as at a later period. This cap has been called an "ovisac," but that is a word already appropriated by zoologists for a case to contain the ova, and cannot therefore be applied to a part of the embryo. There seems also to be no reason why it should not be called the *nucleus*, as the similar part of a Gastropod shell would be. The several interesting points about this nucleus in the Ammonitoidea cannot now be touched upon, but we must confine ourselves to the Nautiloidea.

In these the nucleus presents no discontinuity of curvature, but is merely the natural rounding-off of the form of the shell, or its coming to a point with a larger apical angle. On the exterior surface of this nucleus in the recent *Nautilus* is situated a narrow depression, with its long diameter in the plane of symmetry, and its sides swollen and smooth (Pl. II., fig. 5, *a*). This was first discovered by Dr. Hooke at the end of the 17th century, and published in Derham's 'Philosophical Experiments and Observations' in 1726. Hooke supposed it to be an air-hole into the siphuncle. Barrande, with his usual closeness of observation, did not let this point slip him; but it has been made a special study by Alphæus Hyatt,[1] whose observations are very careful, and his figures very close to nature (Pl. II., fig. 5). He calls this depression a cicatrix or scar, and considers that it marks the passage through which the growing animal escaped from a nucleus similar to that of the Ammonitoidea, but which was not persistent. He remarks on the difficulty of the animal passing through so narrow a slit, though there is no reason why the aperture should not have been larger at first and diminished by an aftergrowth.[2] There is not, however, the slightest proof that there ever was any nucleus beyond what we see, and every probability that there was not. The embryo Ammonite has its first septum at the junction of the nucleus to the later shell, and the siphuncle commences in the former; so in the *Nautilus* the first septum is at the junction of this nucleus with the normal form, and the siphuncle passes into the nucleus (Pl. II., fig. 4). Thus to assume an earlier nucleus involves the assumption of a later development of the siphuncle, for this organ is quite cut off by the shell at the base of the nucleus, where it commences. Doubtless the nucleus differs only in form from that of the Ammonitoidea, and the cicatrix marks the point from which the growth of the shell commenced.

A section of the shell in the plane of symmetry taken along the cicatrix (Pl. II., fig. 4) shows that the siphuncle does not commence exactly opposite to it, but nearer to the convex side of the shell. The surface of the cicatrix (fig. 4, *a*) is very undulating, as though modelled on a loose membrane; but the substance of the shell

[1] "Fossil Cephalopods of the Museum of Comp. Zoology—Embryology."—*Bull. of Mus. Comp. Zool.*, vol. iii. No. 5, 1875.

[2] See Owen, *Proc. Zool. Soc.* 1879.

at this part contains both layers, which are perfectly continuous, and show no signs of the cicatrix having ever been perforated. The outer of the two layers becomes very thick when traced in the section into the concavity of the umbilicus (fig. 4, *b*), and its junction with the nacreous layer becomes very opaque, so as to look black by transmitted light (as represented by Hyatt), but it is not really so. This thickened part has so similar a structure to that of the exterior of a "cuttle bone" as to suggest that it is the rudimentary representative of that part, and also of the Belemnitic "guard." It has almost, if not altogether, died away by the time that the shell has curved round into contact with the convex side. The inner layer is also thicker at the same spot as the outer, but thins out to the cicatrix, the inner layer of which juts, like a subsequently formed septum, upon its inner side (fig. 4, *c*), proving that this inner layer was formed subsequently, and is in point of fact the first septum. The most external layer of the cicatrix and of the thickened part is an extremely thin black deposit, which is afterwards developed only on the inner side, where it forms the dark layer seen on the earlier whorls (fig. 4, *d*).

In extinct Nautiloids the cicatrix is sometimes absent, sometimes it is round, but more often, especially in coiled shells, it is elongated in the plane of symmetry as in the recent form. Not many of the Silurian species show their initial cap, but there are some which have the cicatrix, as will be noticed, in their place. When there is no cicatrix, the last semblance of a reason for imagining an earlier nucleus is taken away. The edges of the cicatrix are often swollen, and the area is of comparatively very small size: Barrande supposes it may have been for the passage of some ligament, or the junction of some floating apparatus. Its closure, however, by an undisturbed band of double-layered shell, the outer one continuous with that of the rest of the shell, seems to exclude the idea of its having ever been open. He admits that a study of the embryology of other molluscs might suggest a more probable explanation; and when we remember that the shells of Gastropods[1] commence in what is known as the "shell-groove," the step is not a long one to conclude that the cicatrix marks the shell-groove of the *Nautilus*. I anticipate that when an embryo *Nautilus* shall be discovered, its first indication of shell will occupy the area now marked out by the cicatrix.

The surface of the nucleus beyond the cicatrix is sometimes smooth, but more often it is marked with longitudinal lines, as it is in the recent *Nautilus* (fig. 5, *b*). These pass often beyond the region of the nucleus for some distance, and affect the whole thickness of the shell; they are therefore doubtless due to a folding of the mantle. To these longitudinal lines are often superadded concentric ones, of rather irregular character, which produce in this way a network: these may be considered as lines of growth. The characters of the nucleus are independent of

[1] See Ray Lankester, "Development of Pond Snail," *Quart. Journ. Micr. Soc.* 1874; and "Developmental History of Mollusca," *Phil. Trans.* 1875.

the ornaments on the adult shell; and, when observable, are available for specific distinction.

Another important matter connected with the commencement of the shell is its position on the curve of motion. Were we to trace back this curve to the pole, we should of course come to an indefinitely small shell; but the actual nucleus is of some considerable size at starting; the effect of which is, that there is a vacuity in the centre of every coiled shell, which may be of large size, or may be more or less filled up by the irregularly shaped nucleus. In the Ammonitoidea the latter is the case; they commence very early in the curve, and the small *initial vacuity* is, in most cases, nearly filled by their globular nucleus. In the Nautiloidea, on the contrary, the vacuity is much more variable; in the more involute forms it is often small, and may be covered up by subsequent deposits, as in the *Nautilus pompilius*; but in the open-whorled groups, as the *Lituites* and *Discites*, there is sometimes a vacuity of as much as one-fourth the whole diameter. This difference sometimes serves to distinguish forms belonging to the two groups, which are externally much alike. On this also depends the number of the whorls in the adult. Considering that the growth of a Cephalopod is continuous, and consequently that every specimen with many whorls must have previously had fewer, I was at one time disposed to attach little importance to the number as a specific character; but, all things being equal, the greater the number of whorls in a given diameter, the earlier must the shell have begun: used, therefore, with caution, the number of whorls is a character of importance, as indicative of the relative size of the embryo.

4. *The Body Chamber.*

On the dimensions of the body-chamber depends the actual form of the animal, and therefore, *à priori*, it should be of considerable consequence; accordingly, in recent attempts at the subdivision of the Ammonites, its length compared to that of a whorl of the shell has been taken as one of the distinctive characters of families.[1] How far particular lengths of body-chamber characterise groups of Ammonites which are united by other features will be considered at a future time; but as far as the Palæozoic Nautiloids are concerned, the great variation in this respect which is found in groups, such as *Orthocerata* and *Trochocerata*, united in all other features, proves it to be of no value as a generic character, and of very doubtful value even as a specific one. In Barrande's *Études générales sur les Céphalopodes*, chapter iv., are given many details of the size of the body-chamber of all Cephalopods that have come under his observation, and the proof of the variability will be found there. In measuring the size of the body-chamber, the ratio of its length to its breadth is most convenient in uncoiled shells, while in coiled ones the ratio of the length to one

[1] Suess, "Ueber Ammoniten," *Sitz. K. Akad. Wiss. Wien*, vol. lii. 1865; and Waagen, 'Die Formenreihe des *Ammonites subradiatus*;' Benecke's 'Beiträge,' Band ii. Heft 2, 1869.

whorl length is better. Of course, when the other elements of the shell are given, these are mutually convertible, and from either we can find by a simple formula the capacity of the body-chamber to that of the whole shell, which latter ratio is no new element unless there are abnormal inflations or contractions.

If the length wants constancy, it is otherwise with the shape. The grouping of united features is such that any peculiarity in the latter is indicative of several others in independent parts of the organism, and consequently I am led to consider the shape of the body-chamber as a generic distinction. Thus in the genera *Orthoceras*, *Cyrtoceras*, *Nautilus*, &c., we have but little change from the earlier shape of the shell. In *Phragmoceras* and its allies we have a peculiarly inflated body chamber; and in *Lituites* we have the curvature lost there; while in *Ascoceras* and *Tretoceras* we find it encroaching abnormally on the septal portion. In the study, therefore, of fossil Cephalopods, the peculiarities shown in this part of the organism are of the highest importance.

5. *The Aperture.*

There are two distinct kinds of aperture among the Nautiloidea, the simple and the contracted. In the simple kind, whatever may be the outline in a transverse direction, the surface of the shell does not bend in towards the centre of the section; in the contracted kind this bending in does take place, and produces a variously formed aperture having quite a different outline to that of the section of the shell. The latter kind is comparatively rare among the Ammonitoidea, and it is chiefly in the suborder we are now concerned with that the distinction is of importance. Barrande places the form of aperture in the first rank of characters, dividing all the Nautiloids into two series by means of it, and complains that other Palæontologists have paid too little attention to it in their classifications. Yet I can see no reason for treating it in any different manner from the rest, or for not judging of its importance by the other characters found constantly associated with it. Among Gastropods, doubtless, the form of the aperture is much used in classification; but this is only when it has some proved relation to the animal; for examples are known among the *Helicidæ* in which a similar lessening of the aperture takes place, without entailing any other changes which are sufficient to separate the animal generically.

The most ordinary form of simple aperture is that in which the sides of the shell are produced into a convex lobe, leaving the dorsal and ventral borders as sinuses between them. The recent *Nautilus* is so shaped, and we know that in it the ventral sinus corresponds to the position of the funnel. That side of the shell in extinct Nautiloids which has the most marked and constant sinus may be assumed with probability to be the ventral side. The amount to which these side lobes are produced, and the corresponding depth of the sinus, varies exceedingly. Among the Ammonitoidea it is not uncommon to find long tongue-shaped productions; but

they are seldom great in any Nautiloid, and in some species are reduced to zero, so that the outline of the aperture becomes a plane curve.

From the simple form the change is very slight to the least complex of the contracted. The slight bending in of these side lobes will narrow the centre and cause the aperture to be roughly divided into two, with a broad passage between. This is essentially the character of all, except a few, of the contracted forms, however modified. This bending in may take place without any other difference of importance being noticed, as in *Trochoceras* and *Lituites*, and it may be very small in amount. It is also very probable that it only occurs in the adult, or even old age, as it is seen only in large specimens of the species. Another simple modification is a bending in on the dorsal side to a greater or less extent, as in the species called *Hercoceras mirum*, and in some others from the Carboniferous rocks of England. When this is united to a bending in of the lobes in a small group called *Ophidioceras*, a swelling of the body-chamber near the aperture, and other peculiarities, it assumes generic importance.

The apertures of *Phragmoceras* and *Gomphoceras* are still further modifications; but, from the extreme variety we meet with, it is obvious that it is brought about by the general contraction of the body-chamber, to which the aperture has to accommodate itself. These apertures consist of three portions: first, the large opening on the dorsal side, which may itself be unlobed or lobed in various degrees; secondly, of a smaller one on the ventral side, and usually on the slope; and thirdly, of a narrower passage between the two. The small aperture is assumed to be on the ventral or funnel side, because of its constancy and of its forming a deeper sinus by its position.

6. *The Ornaments.*

These, when correctly observed, with the changes that take place in them as we pass from the young to the adult, form the most valuable of specific characters in the Nautiloidea. The various kinds are so uniformly distributed as to yield no temptation to use them for greater purposes, though we may conveniently group the species by them for the sake of reference. It is only necessary to define their terminology. They consist usually of ribs, which either run longitudinally, from the apex towards the aperture, or transversely, parallel to the section. These may be either acute or rounded; they may be called separate, if they are narrower than the interspaces, and the transverse ones are undulating if they do not form a plane curve. The minor ornaments are either finer ribs which stand out from the surface, and may be called *riblets*, or impressed lines which alone should be called *striæ*. When these become irregular, they are taken to be lines of growth. If any of the tranverse ornaments have in section a more rapid slope on the side nearest the aperture, they are said to imbricate upwards; if the contrary, downwards. In some cases the

whole ornament slopes downwards or upwards till it meets the next: these are called upward or downward imbrications respectively.

7. *The Septa.*

In the Nautiloidea these are comparatively simple, but they give rise, nevertheless, to several points of interest.

(*a.*) *Their distance apart.*—The first septum begins at the junction of the cap with the normal spiral (Pl. II., fig. 4), and cuts off the former. The first apparent chamber is therefore different from all the rest, and its relative size depends entirely on the shape of the nucleus, and this, in different species, may be either much greater or much less than the second chamber. Starting from the first septum, we do not find them at distances constantly proportional to the diameter. If they were, there would always be the same number in each whorl. In an example, however, of *Nautilus pompilius*, the first whorl has eight chambers, the next has sixteen, and the last half whorl seven. The same want of regularity is found in other Nautiloids. As a rule, the earlier septa are more remote, and the middle ones only retain for some distance their proportionality. The last two or three septa of the adult very commonly differ in distance from the rest. In some rare cases they are more remote, but they are usually closer, and the commonest case is that in which the last one is at half the usual distance. This is doubtless to be regarded as a proof of senility, and the fading of the powers which caused the animal's progression, which was more rapid in youth. Some caution is therefore required in using the distance of the septa to recognise fragments by; but when a complete specimen is before us, it affords a valuable specific character. The *Gomphoceratidæ* and the Silurian *Cyrtocerata* have usually remarkably close septa. The space between the septa may be expressed either as a fraction of the diameter of the whorl, or the number in any given whorl may be stated.[1]

(*b.*) *Their general direction.*—In those of more complicated form we can only express this by a line joining their central point in the ventral to that on the dorsal side. If this passes through the pole of the curve of motion, the general direction may be said to be radial; if not, they have a general slope forwards or backwards. Radial septa will of course make the same angle with the general direction of the whorl as the spiral angle of the curve, and are in one sense oblique. In slightly curved shells, such as *Cyrtocerata*, it is more convenient to call them direct when they are perpendicular to the general direction, whether radial or not, and the same terminology applies to *Orthocerata*, &c. The amount of obliquity varies from one

[1] These are connected as follows *approximately*. If r be the ratio of the distance of the septa to the breadth of the whorl, n the number of chambers per half whorl, d the diameter of the whorl, and u the diameter of the umbilicus,

$$nr = \frac{\pi}{2} \cdot \frac{d+u}{d-u}$$

species to another so continuously, that those with oblique septa are not marked off as a group from the rest, and such a genus as *Loxoceras*, proposed by M'Coy, is not therefore required. If there be ornaments on the shell, it is very usual for the septa to have the same direction as they have; but this is by no means universal, and affords a good specific character.

(*c.*) *Their shape.*—This may be considered dependent on two elements, viz. the *sutures*, or their intersection with the surface of the shell, and the *convexity*, or elevations and depressions on the surface of the septa, bounded by the sutures.

The sutures form plane curves only in uncoiled shells, and even in these they are more commonly concave towards the aperture. If the concavity does not extend from one side to the other, they are called undulating, because they have a wavy-like appearance; the undulation may be either on the sides or on the ventral and dorsal regions. In coiled shells the sutures are perhaps always more or less curved. In the simplest cases the septum shows a single concavity towards the aperture, such as might be produced by the intersection of a sphere with the surface of the shell. When the latter is in any degree angular, like the *Discites* of the Carboniferous rocks, or the subquadrate Silurian forms, it throws the sutures into corresponding angles, which are of quite a different character, therefore, to the angles which in other cases they make on perfectly uniform surfaces. From this we pass to the form exhibited by the recent *Nautilus*, and many fossil ones which have sigmoid sutures. In some the inner part of the suture is concave and the outer one convex, or direct, but in others the arrangement is reversed. Certain of the Nautiloids have very exaggerated sigmoid sutures; while an anomalous group among the *Clymenidæ* have actually an angular lobe on the side. From the important developments which take place in this direction when we enter the Ammonitoids, it might be thought that such *Clymenidæ* ought to be severed from the Nautiloids; but there are no other features to separate them, and a close approach to their form of suture may be found among undoubted Nautili, as in *Nautilus Parkinsoni* from the London Clay. But the most extraordinary departure from the simple form met with among the Nautiloids is in *Ascoceras*. In these the earlier septa are normal, but the last few adhere together in the centre and form but one line; while on one side they are thrown into deep sigmoids with the inner ends joining, and on the other are the short remainders containing the siphuncle, as will be shown at greater length under the description of this genus.

Besides the wide curves of the sutures, there are found in some Nautiloids a minute lobe on the dorsal and one on the ventral region. The former may be admirably seen in the recent *Nautilus*. The dorsal part of the last septum, instead of going straight across, is seen to be deflected backwards in the centre so as to form a small angular lobe only a line in length. This lobe is occupied by a prominence which has a circular depression in the middle, and a mulberry mass in front. Each

of the previous septa leave a furrow on the dorsal surface, which deepens anteriorly beneath the succeeding septum (Pl. II., fig. 2, *b*), and which is doubtless connected with the longitudinal band observed in this position on the surface of the mantle. This small angular lobe of the sutures has a totally different origin from those large ones which characterise the Ammonitoidea, and must not be confounded with them. As to the lobe on the ventral side, it is only found in those species with a ventral siphuncle, and is due to the existence of the siphonal neck, to be immediately described, and hence is also not to be confounded with a true lobe. One or other of these confusions has given rise to the supposed genus *Bactrites*.

The *convexity* of the septa is of course partly dependent on the sutures; if these be concave towards the aperture on the whole, as they are in the Nautiloidea, the septa cannot very well be convex in that direction, unless a reversed inflation were given to them, which is never the case. If corresponding points of the suture on opposite sides of the plane of symmetry be joined by straight lines, a surface would be produced having a ventro-dorsal convexity equal to that of the suture, but absolutely none in a transverse direction. Such septa are not uncommon both among coiled shells and uncoiled. When in the latter the sutures form nearly a plane curve, the septa are almost flat, as in the *Gomphocerata*. The true convexity is that which occurs in a transverse direction, being independent of the shape of the sutures. Among the *Orthocerata* this forms a good specific character, and occasionally in other genera. It is measured by the height of the septum divided by its transverse diameter. In coiled shells the convexity is not uniform, and cannot well be made use of as a character. In the recent *Nautilus*, for example, it is greatest where the suture is convex to the aperture, so that, in spite of sigmoid sutures, in a central section the septa are pretty uniformly concave. This latter feature is known to be characteristic of the Nautiloids, the Ammonitoids having a larger part of the surface convex towards the aperture.

Besides the general convexity, there are two elevations seen on the hinder surface of the septum of the recent *Nautilus* and of some others. The first and least important is a small closed one in the dorsal region, in connection with the small lobe of the septum there (Pl. II., fig. 2, *a*); it is most conspicuous in the young, and gradually fades away in the adult (fig. 2, *c*). It lies upon the furrow of the preceding chamber, and must have been caused by the little elevation on the surface of the mantle which produced the papilla in the body-chamber. It is this lobe which, becoming more conspicuous in the fossil *Nautili*, has given origin to the supposed genus *Bisiphites*, it having been mistaken for a second siphuncle. On the uncoiled *Orthocerata* it cannot be said to be often observed, but in several instances it is present. It is indicated by a line which projects most at each septum and then dies away again, and it has led to such species as *Orthoceras Steinhaueri* of the Carboniferous rocks, which has a siphuncle not marginal, being classed as *Bactrites*. It is perhaps an open question how

far the enormous lobe of the *Tretoceras* found in this position and reaching back more than one chamber is an extraordinary development of this small dorsal prominence.

The second projection is that known as the *neck* of the siphuncle. It is usually open at the posterior end, and so has the shape of a funnel. In the first septum, however, of *Nautilus pompilius* it is closed (Pl. II., fig. 4, *e*). The projection is comparatively slight, on account of the shallowness of the nucleus, and its base rests against the interior of the shell opposite the end of the cicatrix. The siphuncle is thus provided with a *point d'appui*, and in the motion forward of the animal to form the next septum it is enabled to pierce the mantle, so that the second neck is open. It is, however, very long (fig. 4, *f*) on the convex side, where it reaches very nearly across the space between the chambers,[1] and its substance is thrown into irregular folds as of a membrane enclosing too small a tube. The third neck is shorter and is also thrown into folds, and so they gradually assume their normal length. In all the true Nautiloids these necks are directed backwards, like the general convexity of the septa; whereas the reverse is the case in the Ammonitoidea, as was first pointed out by Von Buch.[2] The essential relation between the general direction of the convexity and that of the neck is shown by the fact that in Dibranchiates such as *Spirula*, in which the septa are again concave to the aperture, the neck is situated like that of the early chambers of the *Nautilus*. This, therefore, is not an independent distinction between the suborders.

The early students of the *Orthocerata*[3] laid great stress on the length of the neck; distinguishing as separate groups those in which it reaches back to the next septum, and so providing a complete sheath to the siphuncle, from those in which it is short. In this genus it appears that other characters, as the largeness of the siphuncle, are associated with this form of neck, and hence the subgenus *Endoceras*; but the sheathed siphuncles are met with in other genera, and in fossils it is often exceedingly difficult to say which character the neck had, for both it and the covering of the siphuncle have been so crystallised that their distinctness from each other is lost.

It is a common feature to find these necks[4] ending in an elegant curve, turning away from the siphuncle and forming in some the basis of a mineral deposit.

(*d.*) *Mineral deposits in them.*—The septa themselves are very narrow. The error into which Stokes and M'Coy, among others, fell, of mistaking the crystalline coverings acquired by fossilisation for the septa, has long been exploded. There are found, however, in certain specimens, a different kind of deposit on the septa to the

[1] Hyatt, loc. cit., states that this second neck is not perforated, but is continued round the siphuncle between it and the first neck. My observations show that this is not the case. The figure given by Hyatt shows it was not observed to do so in his specimen, and from the comparative shortness of the third neck it is very improbable that it should.

[2] Von Buch, 'Ueber Ammoniten.'

[3] Münster, 'Beiträge zur Petrefactenkunde;' and Quenstedt, 'Petrefactenkunde Deutschlands.'

[4] It may not be amiss to state that the French call this a "goulot," and the Germans "Düte."

usual crystalline one, which has been shown by Barrande to be due to the animal and not to fossilisation; and he has been followed in this by other naturalists. All one's prejudices are against the organic nature of these deposits; but the evidence leaves the probability strongly in favour of it. (See Pl. XII.) They lie on both sides of the septa, the one nearest the aperture being usually the smallest, since it does not extend so far from the side. The outlines are irregularly mammillated and parallel to the septa, ending off in a prominent curve at last, and sometimes having additional outlying masses. Their structure has a concentric appearance, like chalcedony; and they are generally of a brown colour, consist entirely of carbonate of lime, and are most abundant towards the apex, and on one side of the shell. These characters are so constant as in themselves to point to a connection with the animal, and they are the proofs offered by Barrande. To them may be added the following. Something similar to this must have existed in *O. conicum* and others from the Llandovery sandstones, in which there is a hollow at the same place; and since the effect of fossilisation has been to consume all the calcareous matter, and this with the rest, it can scarcely have been also to produce the deposit. In an example of the carboniferous *Actinoceras giganteum*, a shell which often shows this feature, a horizontal section shows the structure to be peculiar; it is divided into polygons by clear narrow spaces, and the centres filled with excessively fine irregularly radiating dark lines, like so many tassels, or tufts of *Batrachospermum*. This *may* be a mineral structure, like the moss agates, but it is certainly not an ordinary result of fossilisation. The deposits are bounded by a non-calcareous thin band, with patches of black here and there. The mass of the great siphuncle, for which this species is noted, is composed of material of similar appearance and colour; and the boundary is the same thin band with dark particles. This similarity is a great argument in favour of these deposits having a similar origin. But once more: in the process of fossilisation of the specimen examined, the thin septa, where unprotected by them, are usually broken down; but sometimes the deposits are also broken and their fragments carried with those of the septa: they existed therefore before the invasion of the crystalline matter into the interior. For these reasons I am compelled to regard them as belonging to the animal and formed during life. But how formed? Barrande regards them as mantle secretions of limited extent, and founds on their continuity along the inside of the shell an argument against the rapid motion of the animal forward! Their perfect distinctness from the septa, which are marked off by clear lines, their utter irregularity and inconstancy in the same species and the same specimen, and their difference in structure, seem to me to entirely preclude this idea. It is, however, difficult to give a satisfactory account of them. The deposit on the concave side of the septum is continued in most cases along the inside of the shell, until it is cut off by the next septum, whence the latter must have been deposited first; the deposit on the convex side usually gives similar indications of having been deposited after that

on the previous concavity; and throughout the whole deposit the lines are as parallel as they can be to its exterior boundary. These facts seem to suggest that, when the mantle forsook the chamber to form a new septum, the shell became slightly porous; the lacunæ of both layers forming in fact the pores. The air-filled septal chamber would be a drying ground for water with dissolved calcareous matter to evaporate in, the superfluous moisture being absorbed either by the mantle through the pores of the next incomplete septum, or by the siphuncle; some of the impregnated water would also soak through the first septum and form the deposit on its convexity in the previous chamber, both deposits pushing out, and so becoming bounded by the thin membrane that lines the chamber; the structure of which may also be impressed on the deposit, by localising the evaporation to its pores. I am not thoroughly satisfied by this explanation, on account of the difficulty of drying the air, which would soon become saturated, though the fact that these deposits do not reach the siphuncle shows that there might be aëriform communication between all the chambers. In any case, I regard the deposits as of the nature of a disease. It may be worth noting that in the recent *Nautilus* the little calcareous infilling of the corner between the septum and the side of the shell is somewhat similar in nature and position to these, and may have a similar origin.[1]

(*e.*) *Truncation of the septa.*—This was also first observed by Barrande, and to the species which best exhibited it he gave the name *Orthoceras truncatum.* Of course it can only occur in uncoiled shells. Amongst these are some which never show more than a certain number of chambers; the earliest preserved is evidently a late one in the whole series, and on its end are formed deposits not found on the other septa. A species very similar if not identical to *O. truncatum* occurs in Britain (see *infra*, p. 151); the septal end is continuous with the side of the shell and has special deposits on it: a similar instance occurs in *O. Etheridgii.* In like manner the *Gomphocerata* never have a termination towards the earlier end, but the thickness of the septal surface is double that of the others. These features are best accounted for on the supposition of Barrande, that the animal had the power of breaking off the end of its shell at the septa, and of depositing shelly matter on the truncated end. Of course this involves the assumption that the animal could reach so far outside its shell, which must have been therefore more nearly internal than in the *Nautilus.* There is nothing improbable in this; the coiled shells are more within reach than the uncoiled, and doubtless the latter were endowed with some recompensing powers. The numerous isolated septa which are met with in the Ludlow rocks, referred to *O. imbricatum*, are also most satisfactorily accounted for if they were naturally thrown off one by one.

[1] Dr. Dewitz has lately (Giebel's 'Zeit. Ges. Naturw.' Ser. 3, Bd. iii.) described the lines which bound these deposits when they have filled the whole chamber, and therefore come in contact with each other, as supernumerary septa! But the facts adduced are easily explained as above.

The utter absence also in all the known specimens of *Ascoceras* of the remains of any of the undistorted chambers, can scarcely be due to accidents of preservation; but these must have been originally easily separable. The shell of such forms as show truncation is seldom preserved, and it was perhaps thinner than that of others.

8. *The Siphuncle.*

The extreme importance of this organ in the eyes of some naturalists may be judged of by the fact that Barrande occupies more than 1100 large quarto pages in the discussion of it. We have to consider—

(*a.*) *Its position.*—One of the chief characteristics of the Nautiloidea is that this is variable, whereas in the Ammonitoidea it takes up a constant position on the convex side of the shell. This is correlated with its variability in other respects. In the recent *Nautilus*, commencing as it does at the base of the nucleus opposite the end of the cicatrix, it maintains a pretty central position throughout, passing in a straight line through the earlier chambers so as to form a polygon, but taking the curve of the shell in the later ones.

Although there are families entirely or chiefly composed of species with non-central siphuncles, still that position is the preponderant one, and Barrande shows by an enumeration of all known forms that out of 1500 there are 500 with central and 418 with subcentral siphuncles. Moreover, except the *Clymenidæ,* there is no family of Nautiloids, or even genus with more than one species, which can be characterised by the position of its siphuncle. Nevertheless, in such genera as *Orthoceras* and *Nautilus* it is more usually central; while the *Cyrtoceras*, *Phragmoceras*, and *Trochoceras* have it more commonly marginal. If we seek for the connection between the position of the siphuncle and the form and character of the shell, no constant relation can be found, though certain tendencies may be observed which indicate some relation between them, and hence the mere observation of the proportions of central and eccentric positions on the long and short diameters will be of little use. In the first place, we may consider the siphuncle as normally always to be situated in the plane of symmetry. Hence when a shell, coiled or uncoiled, has the long axis in that plane, the siphuncle must be on the long axis, and it is surely the form of the shell which governs the siphuncle, and not the siphuncle the shell. The *Phragmocerata*, for example, are always compressed shells: hence their siphuncle is always in the long diameter. The position is also related to the obliquity of the septa, or of the ornaments, or of both. When the septa are oblique, we may generally anticipate an eccentric siphuncle in the line of slope, and the more eccentric as the slope is greater; sometimes the siphuncle is on the semi-diameter nearest the aperture, but more usually, especially when the eccentricity is not great, it is on the more remote one. Exactly the same may be said of the ornaments, but their slope is more constantly backwards towards the

siphuncle. When the ornaments slope in one direction and the septa in the opposite, as in *O. Grayi*, the two influences balance each other, and we find a central siphuncle. These connections are sufficiently constant to suggest some real relation, though in several cases it may be disturbed by other influences.

The position of the siphuncle is not always constant during the growth of single individuals. In some, beginning eccentrically, it ends by being central; but more often it is central at first, and diverges from the middle line with age. In species which admit of this change, it may take place sometimes earlier than usual, so as to give the idea of a different position throughout. These variations do not nullify the value of the character in the determination of species, but only suggest care in its observation. Another very rare anomaly is the unsymmetrical position. One is tempted to believe that this is due to contortion, but it is found in specimens showing no signs of such treatment. In some cases, perhaps, it may be due to disease, as possibly the *Nautilus anomalus* of Barrande may be the same as *N. vetustus*. There are, however, instances, e.g. *O. intermedium*, in which it is unsymmetrical in all specimens, and then it must be regarded as a specific character.

It is to be noted that, in determining the position of the siphuncle when the septa are oblique, it must not be measured on the septal but on the transverse direct diameter of the shell, since a point truly central will lie on the side nearer the apex in an oblique section of a cone.

(*b.*) *Its size.*—The variations in this are obviously correlated to those of its position, because when it finally settles in the Ammonitoidea at the external border it becomes, and ever remains, filiform in size. Most usually it is small; but it becomes large in two groups from different causes. In one, *Endoceras*, it has a large diameter throughout; in the other, *Actinoceras*, it is swollen between the chambers. The size is not always constant throughout the shell in proportion to the diameter; even in the recent *Nautilus* it is proportionally much larger in the young, and this seems to be the usual variation; in fact, it tends to remain of the same absolute size throughout. The remarkable siphuncles of *O. docens*, Barrande, and that figured by Dr. Bigsby in the *Transactions of the Geological Society*, 2nd series, vol. i. Pl. 30, even show a rapid decrease in the absolute size; but I have not seen any such from British strata. In *Ascoceras*, also, the same is seen; the siphuncle of the last regular septum is large, but that of the distorted ones gets pushed to one side, and its size rapidly decreases.[1]

(*c.*) *Its structure.*—The actual membranous siphuncular tube itself is a soft organ, of which no trace remains in the dried shells. These only show the two exterior coverings of it. In *Nautilus pompilius* the inner of these is a black or dark brown horny tube, which is not strictly continuous. The base of each neck of the septa is swollen internally, and to the hinder part of this swelling is attached

[1] See Barrande, 'Syst. Silur. de Bohême,' vol. ii. Pl. 513.

the horny tube which traverses the chamber and is inserted into the anterior side of the next previous neck swelling, so that it is actually discontinuous at each neck. It appears to be quite inelastic, as seen when dry; but it has certainly contracted in drying, as it does not fill the outer coating, and in the first chamber is drawn away from the first neck, to which apparently it was not attached (Pl. II., fig. 4, *g*). The outer covering of the siphuncle is merely a crystalline exudation from the inner; several long calcareous crystals may be seen attached to the latter, and the whole of the outer coat consists of similar ones held together only by their interlacing (Pl. II., fig. 4, *h*), and crossing each other at all angles. This coat is also continuous from one septum to another, and enters into the concavity of each neck, even in the earliest chamber, whose neck it lines. On the convex side of each septum it is so abundant that it overlaps the end of the neck and covers it on the outside, although it is obviously a subsequent deposit. It is no doubt this mineral deposit which yields the appearance of continuous siphuncles in many fossil shells, in which a more careful examination shows the terminating neck of the septa to be comparatively short. Unfortunately, this simple structure yields very little assistance in determining the nature of the complex bulbous siphuncles so often met with in Palæozoic *Orthocerata*. Fossils containing these have been long ago described under the generic titles *Actinoceras* and *Ormoceras*. In the former of these the siphuncles have been stated to consist of two tubes, of which the inner was connected with the outer by radiating plates.[1] Such plates Barrande has well shown to have no existence. The appearance is brought about by the growth of organic deposits round the necks of the septa, and their increase till they actually meet, and each forms half of the bulb. In this process it is supposed that the siphuncular tube, which was originally of large size, has its diameter greatly diminished and thrown into folds; while the superabundant membrane is squeezed flat in the middle between the two halves of the bulb, and is thus thrown into radiating folds, whose contents have been mistaken for actual plates. That this explanation is in the right direction, at least, a careful examination of any so-called *Actinoceras*, or of Barrande's plates, must convince any one who will take that trouble; and from this it follows that *Ormoceras* is the same thing when the process has not continued so long, and is therefore incomplete. Barrande, however, considers this process to take place entirely on the outside of the siphuncular tube, against which idea are several opposing facts. The outside of these bulbs has quite as definite an outline as the inner tube, or even more so; the concentric deposits round the necks may be easily seen undisturbed, till they grow into contact with the next, or till they have been stopped on the outside by this definite line; but, more particularly, some *Orthocerata*, as *O. giganteum*, show plainly a distinct arrangement of folds on the outside, which pass inwards in the middle of the bulb; and hence the same membrane which makes

[1] See Stokes, *Trans. Geol. Soc.*, Series II., vol. v. p. 705.

the radiating plates is continued over the surface of the bulb. These deposits must therefore take place between the membranous siphuncle and its brown horny envelope; as the deposit grows, it detaches more and more of the envelope in the region of the septum, till at last the two are only connected in the centre of the interval. In some cases, as when the bulbs are not subdivided in the centre, the two must have been altogether detached, and the deposit became continuous between them. In other cases they must have remained attached along longitudinal lines, as when there are longitudinal plates within or folds on the outside of the bulb. These deposits are much too solid to be compared directly to the crystalline external coat of the siphuncle of *Nautilus pompilius*, but they are exudations of the same general nature. Barrande draws a line in his classification between those species whose siphuncles are *nummuloid,* or with the transverse axis greater than the longitudinal, and the *cylindrical,* which are narrow. It is, however, quite an arbitrary line, and the essence of his explanation of the origin of the bulbs is that there is no real difference between the two kinds. In some American and Canadian forms siphuncles have been figured, and actually exist, in which the earlier part is partitioned off by conical septa in the same way as the shell itself is; but none occur in British rocks, unless the doubtful *Piloceras* be of this nature.

(*d.*) *Its functions.*—The old idea of its expanding and contracting, so as to increase or diminish the density of the gas in the chambers, has long ago been exploded, on account of the crystalline friable coat, the continuity of the necks of some species, and the solidity of the organ in others.[1] It is not a ligament or a muscle, for it is hollow and contains an artery. The only plausible functions at present assigned to it are those of nourishing and keeping alive the septal portion of the shell, or of secreting fresh supplies of the gas which may escape. The first of these is due to Searles Wood,[2] and is adopted by Professor Owen,[3] and the second to Keferstein.[4] Barrande, while giving no theory of his own, objects to these on several grounds. The first is the existence of a double envelope, which would no doubt prevent the ramification of veins, but not the exudation of moisture or gas; another is that the septal necks form a continuous tube; but this is scarcely the case, for the friable, and hence porous, outer layer always intervenes between one neck and the next septum. Hence, I think, both of the above functions may be performed, not by the ramification of arteries on the septal surface, of which there is no sign in the bounding pellicles, but by the continual porosity of the exposed parts, by which those pellicles are kept moist, and the organic deposit, both on septa and in the siphuncle, rendered possible.

[1] Yet it has been given as the true explanation without discussion by Dr. Wright, "Lias Ammonites;" *Pal. Soc.* 1880.

[2] Edwards' "Eocene Mollusca;" *Pal. Soc.* 1849.

[3] *Proc. Zool. Soc.* 1879.

[4] 'Palæontographica,' 1871.

9. *The Internal Marks.*

There are several curious marks on different parts of the shell of Nautiloids whose nature is in some instances unknown, though in all probability of importance as connected with the organisation of the animal. These are—

(*a.*) *Vascular marks on the septa.*—These always lie on the concave side; and may be easily seen in the last chamber of *Nautilus pompilius* (Pl. II., fig. 3). They are very shallow, and hence may be easily overlooked. They represent the impressions of circulating vessels in the upper part of the mantle, and ramify from the neighbourhood of the siphuncle, and bifurcate towards the circumference. Since each septum was at one time the end of the body-chamber, similar marks are to be found on the concave side of each, but they do not correspond to any arteries in the septal chambers, which are not in communication with the siphuncle in this way.[1] Similar vascular marks are found on the internal casts of chambers broken off from Silurian Cephalopods, e.g. *O. imbricatum.*

(*b.*) *Bands on the septa.*—In some Silurian forms a raised band in the cast, corresponding to a depression on the concave side of the septum, passes from the siphuncle to the circumference, usually but not always in the line of symmetry. Such are figured on Plate XIV. as belonging to *D. imbricatum.* Nothing corresponding to these is to be seen in the recent *Nautilus*, and they are very rare in the *Orthocerata*, and one can only suggest that they may have been special lines of attachment for the mantle.

(*c.*) *Normal lines.*—This name has been given by D. D. Sandberger[2] to narrow lines which are occasionally seen in the cast running longitudinally, and usually in the plane of symmetry. In some cases they appear raised, in others depressed. One of these can be found in the recent *Nautilus*, on the concavity of the ventral side of the body-chamber, before the septal deposit conceals it, but it is very obscure and narrow. On the dorsal side there is, as already noticed, in connection with the septa, a shallow furrow leading from septum to septum and deepening anteriorly, and this in a cast would produce a well-marked normal line. In some fossil *Orthocerata*, e.g. *O. semipartitum*, this is so prominent, and the deepening at each septum so marked, as to have been taken for the siphuncle. Its real significance, except its connection with a longitudinal line noticed on the surface of the mantle, is still obscure. Occasionally such normal lines or keels are more numerous, and divide the whole surface into equal parts.

(*d.*) *Folds at the base of the body-chamber.*—The surface near the base of the body-chamber, and on the adjacent septa, is sometimes thrown into longitudinal folds, the

[1] And they cannot therefore be adduced as arguments for the vitalising function of the siphuncle. See Prof. Owen, loc. cit., p. 971.

[2] 'Versteinerungen von Nassau.'

deeper parts of which might compare with the numerous normal lines, but the surface between is convex. They are most common in the group *Inflati*.

(*e*.) *Epidermids*.—This name is given by Barrande to curious impressed lines seen on the casts of Nautiloids. They are usually transverse, but occasionally longitudinal; when the former, they are often arranged sigmoidally, but each individual stria does not go far, but its place is taken by others, and they all run into each other. Since they are hollow on the cast they are in relief on the shell, to which they give a wrinkled appearance. When this is seen, it is called by D. D. Sandberger the "Runzelschicht," or wrinkled layer, and is most common on the ventral surface of the penultimate whorl, being due to the dorsal layer of the succeeding whorl; but the transverse epidermids are not confined to any part of the shell. Barrande states that he has seen them on the recent *Nautilus*. They are obviously due to a similar disposition of the surface of the mantle in the locality where they occur. They are most common in the *Trochocerata*, and are very liable to be confounded with ornaments. I have never seen, however, a longitudinal set overlying a transverse set, as Barrande has.

CLASSIFICATION OF THE CEPHALOPODA.

As the *Dibranchiata* have no known representatives in the Silurian rocks, the present question resolves itself into a classification of the *Tetrabranchiata*. Certain groups, however, which do occur in Silurian rocks, have been classed by some authors in the former order, and it is necessary, therefore, to discuss their true position. By M. le Chév. d'Eichwald, the whole of his family of *Orthoceratidæ*, that is, the whole of the uncoiled Silurian Cephalopods, have been so treated. For this there appears no better reason than that the chambered shells of an *Orthoceras* may be compared with the phragmocone of a Belemnite, and the latter is undoubtedly dibranchiate. It may, however, be equally well compared with the shell of the *Nautilus*, and it bears the same kind of resemblance to it that the Belemnite does to the *Spirula*. The great importance of the siphuncle in many *Orthocerata*, the preservation of colour on their shells, and their ornamental

character, together with the constant sinus in their lines of growth on the side in which such a sinus is found in the *Nautilus* in relation to the funnel, the size of the body-chamber, and the thickness of the shell, are all proofs of their having been tetrabranchiate. By Prof. M'Coy the Bellerophons have been considered Cephalopods, and placed in relation to the Argonaut. There is a superficial resemblance between the shells, and this led Ferrussac, Latreille, the elder Sowerby, and apparently Owen, to associate them as M'Coy has done. It was the same with D'Orbigny; but he confesses that after having seen the shell, which he named *Helicophlegma*, which has an extreme resemblance to *Bellerophon Urii*, and which is inhabited by a Heteropod, he could maintain that opinion no longer. In point of fact, however, the resemblance is only superficial, for the shell of the Argonaut being formed by two arms, the line of junction is an irregular one; whereas in the Bellerophon, there is often a median band having transverse and *unpaired* ornaments. It was therefore, in all probability, a mantle secretion.

In excluding the Bellerophons from the Cephalopoda, and in including the *Orthocerata* among the Tetrabranchiates, most naturalists are agreed; but there is much difference of opinion concerning the limits and subdivision of the last-named order. In the great work of Barrande all the classifications proposed up to the date of that publication are exposed at full length and passed in review, and it would not be useful to repeat that exposition. The characters on which these classifications have been founded are:—1. The position of the siphuncle; 2. The form of the sutures; 3. The involution of the shell; 4. The form of the aperture; 5. The symmetry or asymmetry of the shell; 6. The direction of the neck of the septa; 7. The simplicity or complication of the siphuncle. According as one or other of these has impressed an author, it has been made the foundation of his classification, the others being put into the background. By the variation of the order in which they are taken, 5040 different methods of arrangement might be produced, any one of which might be equally right, if the objects to be classified gave us no indication by the history of their appearance and association of what was the true method. But they do give us very remarkable indications of their true relations to each other, and these we must take into consideration to arrive at a natural classification.

In the earlier Palæozoic forms we find the siphuncle playing a very important part, and showing many variations. Now it is simple, now it is complicated; in one it is dorsal, in another ventral, in a third medial. The various species and genera are founded to some extent on these changes; but when we reach the Goniatites, which at their earliest appeared later than the great bulk of *Orthocerata*, and from them pass to the Ammonites, the siphuncle shows no variations, it is uniformly small and on the convex side of the shell, and thus ceases to be that important organ, at least for classificatory purposes, and therefore probably for all purposes, that it

once was, and which it remains in those comparatively few *Nautili* which continued the old group into later Neozoic times. Just so among the Corals: the old *Rugosa*, though said to have their septa in multiples of four, were, in reality, indefinite in the number, while regularity is the character of the newer forms in this respect. Just so among Echinoids: the old *Perisso-echinidæ* had more than twenty rows of plates; but the later forms fixed definitely on this number, and their variations passed to the positions of the mouth and anus. Just so in the Crustacea: the number of somites characterises the lower and earlier orders, till, when the number becomes fixed in the *Podophthalmia*, the variations depend only on the modifications of each. Of none of the other characters can such a statement as the above be made, and thus we arrive at two primary divisions of the chambered Cephalopods. First, those in which the siphuncle is variable in position or character; and secondly, those in which the siphuncle undergoes no change from species to Species.

In point of fact, as is well known, in the latter group, which include the Ammonites and Goniatites, the siphuncle is always filiform and external; but this is no essential part of the definition: there are *Orthocerata* and *Nautili* whose siphuncle is so too; but they do not show the other features of the Ammonites, and hence in them this position and form is only one of the many varieties.

In addition to these characters of the siphuncle which may be observed in the adult shell, Munier-Chalmers[1] has shown, and I can confirm to a great extent his observations, that the commencement of the siphuncle shows considerable differences. In the first group it commences at the base of a conical or hemispherical first chamber; in the second group it begins irregularly in the centre of a globular first chamber, as it does also in the Belemnites. It is thence argued that the Ammonites are not Tetra- but Di-branchiate; whether this be so or not, their separation from the Nautiloids becomes still more marked, and we are justified in regarding them as belonging to different suborders, in whatever order we may ultimately place the Ammonites.

Nothing of so great morphological importance distinguishes the *Orthocerata* from the *Nautili*, and they cannot therefore be separated into groups of the same value as the above. Barrande makes a third group, intermediate between the Nautiloids and the Ammonites, to receive the Goniatites and Clymenias, which, he says, cannot be separated. It is to be noted that D'Orbigny, whose classification is adopted by Edwards in his 'Eocene Mollusca,' published by the Palæontographical Society, also separates the Clymenias as a distinct family on account of their internal siphuncle, a method of procedure in the highest degree artificial, since it would lead two allied species of *Cyrtoceras*, or even varieties of one species as *C. quasi-rectum*, to be classed in two different families. It is for far other reasons that Barrande has made a third family, and these must be discussed with more care. It must be admitted that of all

[1] 'Comptes rendus,' tom. lxxvii. p. 1557.

the Ammonitidæ, the Goniatites, especially the group of the *Nautilini*, are most nearly allied to the Nautiloids; while the Clymenias, and particularly those which have angular sutures, are nearest among Nautiloids to the Ammonites. Indeed, in the matter of sutures these two genera overlap, and they must necessarily, therefore, be closely allied. They are, however, sharply distinguished by the position of their siphuncle: in the one it is as constantly internal as in the other it is external. Barrande cites the cases of *Cyrtoceras* and *Phragmoceras*, to show that this is of little value. These genera, however, have species whose siphuncles are neither internal nor external, and the elements of that organ are either simple or dilated—they have, in fact, variable siphuncles. Whereas the difference between a Clymenia and a Goniatite is not the actual position of the siphuncle, to rely on which would be to repeat the error of D'Orbigny, but that in the latter it has finally settled down into that position, from which it never afterwards varied. The external siphuncle was a success when associated with complex sutures, whereas the internal one was a failure both in *Clymenia* and *Aturia*, both of which were extremely short-lived forms, in spite of these folds in their septa. But are not the Goniatites merely examples of Nautiloids, which, like some others, happen to have this variety of the siphuncular characters? They might be so considered if they were few in number and of various ages; but they are the ruling forms in Carboniferous times: their sutures become in some cases almost as complicated as one of the simpler Ammonites, and they possess the same globular first chamber as the latter. It is obvious, therefore, that they are no mere offshoots, as the Clymenias might be, but part of the great evolutionary stem. As the lowest of the Ammonitidæ, they have not yet acquired all the peculiarities of the family, and in particular they have a backward and not a forward siphuncular neck to their septa. This detail seems to be in part indifferent, as is seen from the genera *Nothoceras* and *Bathmoceras*, which, with all other characters of Nautiloids, agree in this respect with Ammonites (see p. 53). Although Barrande gives the characters of the aperture of the Goniatites as agreeing with the Nautiloids, we meet with all kinds of aperture, except the contracted, both among Goniatites and Ammonites, so that this is not really a distinctive character. The non-persistence of the siphuncular envelope, said to be characteristic of both genera, seems to me of very minor importance. This appears to be the only character which separates *Clymenia* from the Nautiloids, except the lobes in the sutures, which may be very well matched in *Nautilus sinuatus* and others. There is therefore no ground for the establishment of a third group. The two suborders are characterised by the following common features.

Suborder NAUTILOIDEA.—The siphuncle is variable both in position and structure; it unites with the septum by a neck which ordinarily, but not universally, points backwards, and commences at the base of a conical first chamber. The sutures are moderately simple, the more acute parts pointing towards the aperture.

Suborder AMMONITOIDEA.—The siphuncle is constant, being always filiform and external; it unites with the septum by a neck, which ordinarily, but not universally, points forwards and commences in the centre of a globular first chamber. The sutures are complex, never entirely without lobes, the more acute parts pointing from the aperture.

Since, with the single exception of a possible Goniatite, the whole of the Silurian Cephalopoda belong to the first suborder, the classification of the Ammonitoidea will not be at present touched upon. Although the genera of Nautiloids actually founded at the present time are enough, and more than enough, to include all the known forms, the arrangement of these genera in groups so as to indicate their natural relations to each other, which has been attempted by many writers, has not yet to my mind been satisfactorily accomplished. The object is not to make a mere analytical table, without reference to the history of the group; but to show the connection between the relations in structure, and the relations in time. The nearest arrangement to nature is that of M. Barrande. The character taken by him to be of the highest importance is the shape of the aperture, which he considers gives the shape of the head. This, no doubt, is of extreme importance, and yet, as it seems to me, by a too rigid application of this character we are led to an unnatural separation of forms. In one group, in fact, the contraction of the aperture is associated with other differences, and these together form a natural assemblage; in another group, the aperture, less markedly contracted, has little influence on other points of structure, and is a matter of comparative indifference. On the other hand, M. Barrande does not employ the position of the siphuncle as a classificatory character among the Nautiloids at all, thereby differing from most authors; but this is accounted for by his not recognising the Clymenias as Nautiloids, and his passing over the Trocholites in silence, these being the only genera in which the siphuncle is characteristically constant. Without, however, further discussing the grouping of the Nautiloids by other authors, I will proceed to state how it seems to me that Nature herself has grouped them. The earliest, and at the same time the most important group, is that of the *Orthocerata*, whose character is that of extreme simplicity. The curvature is zero, the body-chamber is of the same shape as the earlier part, and the aperture is simple. From the shape of the transverse section, or from peculiarities connected with the siphuncle, the genera *Gonioceras*, *Tretoceras*, *Endoceras*, *Actinoceras*, *Bathmoceras*, *Bactrites*, and others have been formed, none of them showing such a general departure from the original type as should justify a separate grouping. The simple addition of curvature, which may vary in amount from nearly zero to sufficient to almost make a whorl, introduces us to the genus *Cyrtoceras*, which runs parallel with the *Orthocerata*, and is found in almost all the strata in which the latter occur. It has few subgeneric varieties, *Trigonoceras* being the most peculiar. All these form one natural group, which we may characterise as the

Conici. Diverging from this, and more restricted in time, is a remarkable group, which, with a generally straight or somewhat curved axis, as in the former series, has so strange an appearance as at once to be separable. This appearance depends not so much upon the shape of the aperture, which is very various, as upon the general inflation of the shell, so that, as a whole, it is fusiform, pyriform, or flask-shaped. This inflation is accompanied usually by some other peculiarities of the body-chamber. Either the aperture is contracted, or distorted septa are formed in it, or both are combined. Moreover, the septal surfaces are commonly flat, and the earlier septa often break off naturally. This group contains the genera *Phragmoceras*, *Gomphoceras*, *Poterioceras*, and *Ascoceras*, and may be characterised as the Inflati. The other two groups of Nautiloids run in some sense parallel to these, but have so great a curvature that they form what are known as whorls, which may or may not be, but generally are, in contact. This arrangement has permanently succeeded the former, or conical, as it is represented in the living *Nautilus*, and, when united with other modifications, produced the dominant family of the Ammonitoidea. Although the great curvature does not seem to be associated with any other general peculiarities of consequence, yet this fact of its superseding the small curvature is of itself sufficient to justify us in regarding it as of sufficient importance to characterise a group, which, containing the genera *Nautilus*, *Gyroceras*, *Trocholites*, *Clymenia*, *Nothoceras*, and others, may be called the Spirales. Of the above genera *Gyroceras* is the intermediate form, leading to the most curved of the *Cyrtocerata*, but more naturally grouped with the *Nautili*. The *Trocholites* and *Clymenia* form a remarkable offshoot, which have been even thought worthy of separation from the whole family of the Nautiloids. They are not, however, more remarkable than the *Tretoceras*, *Endoceras*, or *Ascoceras*, among the *Conici* and *Inflati*, and the modification is the same; namely, a deep depression on the marginal surface of the septa. Finally, separated from the normal *Spirales* by some peculiarity of form, either a want of symmetry, or a loss of curvature producing a straight body-chamber, or great changes of curvature, are a number of genera of peculiar aspect, which may be conveniently associated together as Irregulares. Such irregularities of form appear to have been attempted at various epochs; just as we find in later times the *Turrilites*, *Helicoceras*, and *Hamites*, among the Ammonitoidea, but they were never very successful, and one is at times in doubt how far they are worth distinguishing from the normal forms. Whilst amongst the *Conici* the irregularity took the character of inflation, so commonly as to throw other variations into the shade, in these *Spirales* there is no preponderance of one form of irregularity over another, though the most common is a want of symmetry. The genera composing this group are the *Trochoceras*, *Lituites*, *Ophidioceras*, and *Cryptoceras*. We thus have the following table of the genera of Nautiloidea.

Suborder NAUTILOIDEA

(having a variable Siphuncle).

Group I. *Conici.*—Curvature slight or none; form conical and regular.	Shell straight: *Orthoceras.*	Siphuncle very large and lateral: *Endoceras.*
		Siphuncle complicated: *Actinoceras.*
		Septa with a deep depression: *Tretoceras.*
		Septa bent forward over the siphuncle: *Conoceras.*
		Section fusiform: *Gonioceras.*
	Shell curved: *Cyrtoceras.*	Section triangular: *Trigonoceras.*
		(?) Siphuncle with conical sheaths: *Piloceras.*
Group II. *Inflati.*—Curvature slight or none; form inflated and irregular.	Shell slightly curved, aperture simple: *Poterioceras.*	
	Shell straight and septa simple, aperture contracted: *Gomphoceras.*	
	Shell curved and septa simple, aperture contracted: *Phragmoceras.*	
	Later septa distorted: *Ascoceras.*	
	Also with aperture partially contracted: *Glossoceras.*	
Group III. *Spirales.*—Curvature considerable; form simple.	Whorls in contact: *Nautilus.*	Siphuncle internal, in a depression: *Trocholites.*
		Also with more or less angular sutures and whorls uncovered: *Clymenia.*
		Also with involute whorls: *Aturia.*
	Whorls out of contact: *Gyroceras.*	Whorls uncovered: *Discites.*
		With peculiar siphuncle: *Nothoceras.*
Group IV. *Irregulares.*—Curvature considerable but variable; form irregular or unsymmetrical.	Unsymmetrical: *Trochoceras.*	
	Curvature lost in the body-chamber; whorls out of contact [?]: *Lituites.*	
	Whorls in contact and with a complex aperture: *Ophidioceras.*	
	Curvature changing; body-chamber inflated: *Cryptoceras.*	

It will be observed that the contraction of the aperture goes for very little in this arrangement, though its importance in some cases is acknowledged. The reason of this is that it seems possible for the aperture to be contracted without making any other notable change in the animal, as when a *Nautilus* becomes a *Hercoceras* of Barrande, a *Trochoceras* becomes an *Adelphoceras*, a *Lituunculus* of Barrande becomes a *Lituites*, or an *Ascoceras* becomes a *Glossoceras*. In these cases the contracted aperture appears to be of little importance compared with the other features. On the other hand, *Phragmoceras* and *Gomphoceras* differ from the corresponding forms *Cyrtoceras* and *Orthoceras* in the general structure of the shell, independently of the aperture, which thus may be omitted from the definition.

The value that should be placed on such curious deviations from the usual shape of the septa in the region of the siphuncle, as are seen in the rare specimens named by Barrande *Nothoceras* and *Bathmoceras*, must almost necessarily be a matter of mere individual opinion. I am not disposed to place much weight on it, as Nature herself does not seem to have done so, but rather to reverse the argument, and to learn from these exceptions that the direction of the neck is not a matter of supreme importance.

DESCRIPTION OF THE GENERA OF NAUTILOIDEA.

SUBORDER NAUTILOIDEA.

GROUP I. CONICI.

Genus ORTHOCERAS, Breyn.

1732. ORTHOCERAS, Breynius, 'Diss. Phys. de Polythalamiis.'
1823. ORMOCERAS, HURONIA, Stokes, 'Trans. Geol. Soc.' [=subgenus *Actinoceras*].
1824. ACTINOCERAS, Bronn, 'Leth. Geogn.' [=subgenus].
1829–37. MELIA, &c., Fischer, 'Oryct. Gouv. Moscou.'
1834. CONOCERAS, Bronn, 'Leth. Geogn.' [=subgenus].
1838. CONOTUBULARIA, Troost, 'Mém. Soc. Géol. France.'
1841. BACTRITES, Sandberger, 'Verst. Nassau.'
1843. KOLEOCERAS, Portlock, 'Geol. Rep.'
1844. CYCLOCERAS, LOXOCERAS, M'Coy, 'Carb. Foss. Ireland.'
1847. ENDOCERAS, GONIOCERAS, Hall [=subgenera].
1850. STENOCERAS, D'Orbigny, 'Cours de Pal. stratigraphique.'
1858. TRETOCERAS, Salter, 'Quart. Journ. Geol. Soc.' [=subgenus].
1860. COCHLIOCERAS, TREMATOCERAS, &c., Eichwald, 'Leth. Rossica.'
1867–74. BATHMOCERAS, Barrande, 'Syst. Sil. Bohême' [=subgenus *Conoceras*].

History.—The genus *Orthoceras* was first instituted by Breyn in the year 1732, for the well-known straight Nautiloids, and no additions were made till 1823, when Dr. Bigsby described, in the *Transactions of the Geological Society of London*, some remarkable siphuncles from Lake Huron, to one of which Bronn gave the name *Actinoceras*, and to the others Stokes applied those of *Huronia* and *Ormoceras*.

These three will be described further on as *Actinoceras*. He also figured an *Orthoceras* with remarkable chevrons over the siphuncle, which Bronn afterwards called *Conoceras*. In 1829 and 1837 Fischer de Waldheim named some fragmentary specimens *Sannionites*, *Epitonites*, *Callirhoë*, and *Melia*, the latter representing an *Orthoceras* with a complicated siphuncle, being afterwards called *Thoracoceras*. In 1838 Troost proposed to separate the examples with a large bulbous siphuncle as *Conotubularia*. In 1841 Sandberger established a genus *Bactrites* for species with so lateral a siphuncle that it seemed to form a lobe in the septa; the same was afterwards called *Stenoceras* by D'Orbigny. In 1843 Portlock described as forming a new genus, characterised by the possession of a sheath, some *Orthocerata* grown over with some *Hydractinia* or other organism, applying the name *Koleoceras*. M'Coy attempted a subdivision of the genus in 1844, by calling the species with transverse ribs *Cycloceras*, and those with oblique septa *Loxoceras*. The same year saw the establishment of the subgenus *Endoceras* by Hall, on specimens with large lateral siphuncles,

previously named *Cameroceras* by Conrad, but not described; a siphuncle of the same group was afterwards named *Colpoceras* by Hall. The same author also founded in 1847 the subgenus *Gonioceras* for species with a fusiform transverse section. In 1858, Salter founded his genus *Tretoceras* on the specimen already figured and described as *Orthoceras bisiphonatum*. In the 'Lethæa Rossica,' published in 1860, Eichwald gives five new names: *Cochlioceras*, *Trematoceras*, *Dictyoceras*, *Heloceras*, and *Nothoceras*, the first three of which had been published by him previously, the first and last of which are *Endocerata*; the second has deposits about its siphuncle; the third is covered by a network, possibly Polyzoan; and the fourth has a small tubercle (or depression on the shell) on the normal line, but none are worthy of separation. Of more recent years the tendency has been to unite rather than to separate genera, except among the Ammonites, and no dismemberment of *Orthoceras* has therefore been proposed.

Description.—The genus *Orthoceras* includes all those Nautiloids which are straight throughout the greater part, at least, of their length, and whose body-chamber is a simple continuation of their septal portion. The form of an *Orthoceras* is the nearest approach to a mathematical cone. The rate of increase is very variable, giving rise to the two groups of *Longicones* and *Brevicones*; it is, of course, always greater in the young, the apex being invariably more or less rounded off. In some species it becomes zero at last, or even negative, the body-chamber decreasing in size; nevertheless there is no inflation, the sides being approximately straight, and the earlier part, in the latter case, being more usually lost. The body-chamber is very variable in length, the more cylindrical forms naturally showing the greatest extension, but giving rise to no natural subdivision of the genus. The aperture is usually similar to the cross section, but mostly presents a sigmoidally curved outline on the conical surface; it is occasionally indicated by a rapid contraction or expansion, but seldom by any thickening of the shell. The surface ornaments are very variable, and may be used in grouping. They may be transverse ribs, or striæ, or longitudinal finer ribs, or a network, or all these combined; these have no relation to the septa, except that it is more common to find the latter in the interval between the ribs when these are transverse. Changes with growth constantly take place in the ornaments; the most common being the loss of early transverse ribs, or the dying away of the finer longitudinal ones. The internal cast does not always correspond to the exterior ribs, the latter occasionally occupying the position of furrows on the former, while the cast is often smooth when the exterior ornaments are fine; the actual surface, in fact, can only be certainly stated to be unornamented when fine lines of growth can be detected. The shell has a tendency to split into two or three layers, which are occasionally covered by structural marks easily mistaken for external ornaments: some species exhibit bands of colour. The septa are usually, but by no means always, parallel to the ornaments, when the latter are transverse;

they are more commonly direct in those with longitudinal ornaments, the most oblique being found among the smooth species. The great majority have no curvature of their own, but a few show undulations independent of their obliquity. Their distance is utterly variable from species to species, and has a usual tendency to be greater in the young and to become rapidly less at last, though this latter tendency is not so marked as in the *Inflati.* Their convexity is usually considerable, flat septa being the exception. It is almost always to this genus that detached septa belong. The siphuncle is a very variable organ, both as to position and size, and its variations seem to have no definite relation to those of the other elements. The more common form is the cylindrical, and the more usual position is near the centre. There are undoubted instances in which it is unsymmetrically placed.

Subdivisions.—The earliest subdivision proposed was that of Quenstedt in 1836, in his 'De Notis Nautilearum Primariis,' which, not being founded on any particular organ, still remains one of the most natural. He recognised—

1. *Vaginati*—with large lateral siphuncles, now the subgenus *Endoceras.*
2. *Cochleati*—with large nummuloid siphuncles, forming now a great part of the subgenus *Actinoceras.*
3. *Gigantei*—for *Huronia.*
4. *Regulares*—with smooth surfaces.
5. *Lineati*—with longitudinal ornaments.
6. *Undulati*—with feeble transverse undulations.
7. *Annulati*—with stronger transverse ribbing.
8. *Inflati*—in which the body-chamber approaches the form seen in a *Gomphoceras.*

There were also included the *Graptolites*, but these were subsequently withdrawn.

M'Coy practically attempted a subdivision of the genus by the introduction of new names, and, like Quenstedt, he borrowed his characters from various parts of the shell.

De Koninck, in his 'Animaux Fossiles,' 1844, divided the *Orthocerata* of the Carboniferous rocks into the following groups:—

1. *Gracilia*—having a long cylindrical form and simple siphuncle = *Regulares* of Quenstedt.
2. *Conoidea*—with a rapid rate of increase.
3. *Elliptica*—having an elliptic section; practically the same as the *Loxoceras* of M'Coy.
4. *Nummularia* = the *Cochleati* of Quenstedt.
5. *Annulata* = the same group of Quenstedt and the *Cycloceras* of M'Coy.
6. *Lineata* } = the same groups of Quenstedt.
7. *Inflata* }

It is thus seen that the naturalness of Quenstedt's grouping is recognised, as the

only differences are due to the occurrence or absence of such forms as constitute groups not common to the two.

Other subdivisions have been incidentally proposed, but they are not of sufficient importance to notice, with the exception of that by Barrande in his classical work on the Silurian Cephalopoda of Bohemia. That author had so much material before him, that he clearly recognised the overlapping of several of the above groups, and in consequence proposed an entirely new one. Marking off *Huronia*, *Endoceras*, and *Gonioceras* as subgenera, he divides the rest into two series: 1. *Brevicones*, in which the apical angle is 14° or more; 2. *Longicones*, in which it is less than that amount, the line being drawn where fewest species lie. The number of species in the former group is too small to admit of any further subdivision, but the latter form no less than sixteen groups, to which names are not assigned, and which are founded on the ornaments of the surface. While the primary subdivision is most useful, the distinctions between the minor groups are in practice too fine to be available, especially when it depends on the direction of the imbrication of transverse lines; while the distinction of cylindrical and nummuloid siphuncles is not made use of.

Culling, therefore, from each its excellences, and remembering that all belong confessedly to one genus, and therefore admit of no accurate delimitation, we may group the *Orthocerata* as follows:—

Excluding *Actinoceras, Endoceras, Tretoceras, Conoceras,* and *Gonioceras*, the genus consists of—Group I., Brevicones; Group II., Longicones. The first group are so thoroughly distinct, and at the same time so rare, that any further subdivision is unnecessary, especially as their ornaments are, as a rule, feebly marked. The second group may be classed as: 1. *Annulati*—having transverse ribs throughout the septal portion, and not confined to the apex. 2. *Angulati*—having longitudinal ribs. 3. *Lineati*—having fine ornaments, consisting of riblets or striæ, longitudinal or transverse, or both. 4. *Imbricati*—with imbricating lamellæ turned either towards the aperture or the apex; and 5. *Leves*—having no ornaments beyond lines of growth, except near the apex. With this latter group must be temporarily placed all species whose external surface is unknown.

Subgenera.—1. Actinoceras.—This group has been generally adopted as a distinct genus, but Barrande rejects the name altogether, on the ground of its being founded upon an error. He considers that the supposed internal tube does not exist, and that both it and the radiating lines are merely intervals between the organic deposits round the necks of the septa, which come into contact, except at the radiating lines. That this is the true cause of the form of the internal structure of the siphon, scarcely admits of a doubt after an examination of the numerous longitudinal sections, showing all stages of the deposits, from simple rings to masses occupying the whole siphuncle, which that author gives. Nevertheless there are indications that the internal tube does exist in the form of an inner siphonal membrane. The exterior

membrane forming the covering of the bulb is not only thrown into folds, which reach from septum to septum, but these folds pass into the body of the bulb along the central line, and are seen when the bulb is split in half, as is often the case with Carboniferous examples, to end round a central circle. There could be no drawing in in this way if there were no internal tube to hold to. In some examples also, not as yet recognised among British fossils, there are vertical lamellæ passing inwards, and these also must have had some internal support. We know that the living *Nautilus* has two envelopes to its siphuncle, and in *Actinoceras* they were both of a character suitable for preservation. It must be admitted that other genera of Cephalopods have similar structures, and that logically they ought to be separated into subgenera; but we here reach questions of convenience merely. The names *Ormoceras* and *Huronia* are founded on mere variations in the form of the siphuncle or in its internal structure, and may well be merged in *Actinoceras*.

2. Endoceras.—In addition to their large and usually[1] lateral siphuncle, the *Endocerata* possess the peculiarity that the neck of each septum is continued backwards into the cavity of the next previous one, so that the siphuncle has a complete shelly envelope. Within this large siphuncle is often found some smaller *Orthoceras*, with its aperture in the same direction as that of the enclosing one. These are often covered by a smooth deposit fitting over them so as to be conical. This latter is supposed by Hall to be a sheath, which he calls hence an "embryo sheath." In some examples there are more than one of these, each fitting into the previous sheath. The base of the siphuncle is often filled with a calcareous deposit, which is also composed of conical sheaths, but which often shows no signs of structure, being solid throughout. Barrande considers the "embryo sheaths" to be merely casts of the part of the siphuncle not filled with organic deposit—an idea which is rather difficult to reconcile with the existence of several sheaths one within the other—unless these outer ones are made of the organic deposit, and not of the infilling of the siphuncle, in which case only the inner one can be the cast; on the other hand, the so-called embryos do not appear, by the size and character of their siphuncles, to be of the same species as their so-called parent. To this subgenus the fossils described by Billings as *Piloceras* belong, being undoubted *Orthocerata*, with similar siphuncular deposits.

3. Tretoceras.—One part of the body-chamber, occupying, in the type, a lateral position, is prolonged backwards for the distance of several septa, but for how many is unknown, as is also its termination. The earlier septa are slightly dragged back by this so as to form a lobe in its neighbourhood; but as the prolongation passes by the septa, it would appear to have been attached to the shell independently of them. This has nothing whatever to do with the siphuncle, which in the type is subcentral and nummuloid, but might obviously have any other character. The siphuncle of a

[1] Barrande describes some with subcentral siphuncles.

Nautilus is an organ occupying a definite relation to its internal organisation, and to mistake a backward prolongation of the body for a second one is simply to confound superficial resemblances with actual homologies. Salter compared his genus to a *Gonioceras*, in which the angular portion had been bent round so as to enclose a tube; but in this case we should have found the tube continuous throughout, and not ceasing in the body-chamber as it actually does. Neither of the other species referred to this genus[1] appear to me to have any relation to it, but to present other peculiarities of quite distinct character, and serving only to show that such peculiarities are of subgeneric value only. Its true relations, other than to the typical *Orthoceras*, appear to be to *Endoceras* and *Ascoceras*: for if the backward prolongation of the body had included the position of the siphuncle, it would have been difficult to distinguish it from the former; and if it had been of greater size, so as to affect the general shape of the septa and produce distortion, we should have a form representing among the *Conici* the latter genus among the *Inflati*.

4. CONOCERAS.—The septa bend forward in the neighbourhood of the siphuncle, which is lateral, and meet at an angle forming a chevron. This is exactly the contrary direction to what is usual for the neck in *Orthocerata*, and it is doubtful how far the part over the siphuncle really represents the neck, as it is angular and reaches forward three or four septal spaces. In any case the structure is so peculiar as to require at least a subgeneric distinction. The other character given by Barrande to *Bathmoceras*, which is otherwise a synonym of this,—namely, that the last two or three septa are usually found incomplete,—is of no value, since many *Orthocerata* of ordinary character, *Phragmocerata*, and even *Ammonites*, show similar incomplete septa, dependent probably on accidents of preservation.

5. GONIOCERAS.—The section is flattened and fusiform, instead of making any approach to a circle or ellipse. This appearance *may* be due to preservation; but, in the absence of any proof of this, the name must be allowed to stand.

Range.—The genus *Orthoceras* has its earliest representatives in the Upper Tremadoc rocks, and attained its maximum in the Upper Silurian. There were many representatives in Devonian and Carboniferous rocks in every fossiliferous locality. The Permian species are reduced to three, two of which are American, and the other from Thuringia; while a greater number reappeared in the S. Cassian and Hallstadt beds, and others of the same age have been identified in the Himalayas and California.

[1] *T. semipartitum*, Salter, and *T. parvulum*, Barrande; the latter, as the author indicates, belongs to the so-called *Bactrites*.

Genus CYRTOCERAS, Goldfuss.

1832. CYRTOCERAS, Goldfuss, in Dechen's translation of De la Beche's 'Geol. Man.'
— CAMPULITES, Deshayes, 'Encycl. Méth.' iii. [= endogastrica].
1844. TRIGONOCERAS, M'Coy, 'Carb. Foss. Ireland' [= subgenus].
— CAMPYLOCERAS „ „ „
1850. APLOCERAS, D'Orbigny, 'Pal. strat.' [= mediogastrica].
1858. PILOCERAS ?, Salter, 'Quart. Journ. Geol. Soc.'
1865. CYRTOCERINA, Billings, 'Pal. Foss. Can.' [= endogastrica].

History.—The earliest name applied to curved *Orthocerata* was that of *Campulites*, but its author, Deshayes, restricted it to those with a siphuncle on the inner side; and as the greater number of forms have this organ external, the name *Cyrtoceras*, first applied by Goldfuss, without restriction as to the position of the siphuncle, has been more generally adopted for the whole group. Quenstedt considered these as forming a subgenus of *Lituites*, defining the latter merely by its curvature. On the other hand, De Koninck, in his 'Animaux Fossiles de Belgique,' gives the name a wider signification than usual, by including *Phragmoceras* within its limits. M'Coy attempted to break up the genus, by applying to the species with a triangular section the name *Trigonoceras*, which representing a remarkable form may, perhaps, be retained as a subgenus; and to those with a circular section, the name *Campyloceras*, which has never gained acceptance. D'Orbigny, in his 'Cours de Paléontologie stratigraphique,' relying too much on the position of the siphuncle, applied the name *Aploceras* to those in which it is central, ranging them with the Nautiloids, and placed those with an external siphuncle among the Ammonitoids. Finally, Billings, in his 'Palæozoic Fossils of Canada,' invented the term *Cyrtocerina* for the species with an internal siphuncle, which is at best, therefore, a synonym for *Campulites*.

Description.—The transverse section is most usually elliptic, having the longer axis in the plane of curvature. It is, however, sometimes transverse, and not infrequently oval, in which case, according to Barrande, the smaller end is usually accompanied by the siphuncle. Species with circular sections are rare, and with triangular ones still more so. The rate of increase is usually great at some period of life, so that the *Cyrtocerata* correspond chiefly to the brevicone *Orthocerata*, and have their total length not many times their greatest diameter. Hence a curved fragment, if the curvature be slight, might be suspected to be the earlier portion of an *Orthoceras*; if the curvature be great, to belong to a *Trochoceras*. In some of the species described by Barrande, there is a diminution in size towards the aperture, but this does not produce an appearance of inflation of the body-chamber such as is seen in *Phragmoceras*. The body-chamber is usually large in proportion, and is invariably so in the British forms. Barrande, however, shows that the longer

forms have usually shorter body-chambers and external siphuncles; and thus they form so peculiar a group, that if the genus were to be split up, it would be advisable to set these apart as distinct. The aperture is always simple; though, as the shell appears to have been thin, it not infrequently happens that the pressure of the rock has forced the edges closer together than they would naturally be, and gives rise to a false appearance of contraction. On well-preserved specimens there is often a thickening of the shell below the aperture.

The *Cyrtocerata* of the newer Palæozoic rocks are often remarkable for their complicated ornamentation, which runs in both longitudinal and transverse directions; but among the Silurian species ornament is rare, and is almost entirely confined to transverse folds or riblets, and the shell is so thin that external and internal surfaces are alike: some species show traces of colour. The distance of the septa is usually slight, and the last two are often closer together than the rest; they are of slight convexity, and more often slant forward on the convex side, approximating to the direction of the polar radii of their curvature, and have a slight natural concavity forwards. The siphuncle is almost always small, so that, in spite of the closeness of the septa, the elements are usually longer than broad. They are, however, almost invariably more or less inflated between the septa, and resemble beads or invaginated cups. The siphuncle usually lies at the extremity of the diameter, either on the convex or the concave side; but by no means constantly so. These two positions have given rise to the grouping of the genus, and they are interpreted to mean, not that the siphuncle in one group arose from a different part of the body to that of the other group; but, taking the siphuncle as a fixed point, one group had its curvature in the opposite direction to that of the other.

Divisions.—The first division was proposed by De Koninck in 1844, who groups them as: 1. *Cyrtocerata phragmocerata;* 2. *C. lævia;* 3. *C. ornata.* The first of these groups, which for that author includes all species with an internal siphuncle, must fall into some other, as it is impossible to include the *Phragmocerata* in this genus. The other two groups are of importance, as the third may be said to be nearly excluded from Silurian rocks. The Doctors Sandberger, in 1850, also divided the *Cyrtocerata*, according to their ornaments, into four groups,—viz. the smooth, the transversely ornamented, those with a network, and those with longitudinal ornaments. Giebel, in his 'Cephalopoda der Vorwelt,' made a primary subdivision according to the shape of the section; practically founding the subgenus *Trigonoceras*, without giving it a name; the remainder he subdivided into two groups, according as their ornaments were transverse or longitudinal. Barrande divides them into two series, according to the position of the siphuncle: I. *Exogastric*, in which that organ is external; II. *Endogastric*, in which it is internal. In these two groups he includes those whose siphuncle, though near the centre, inclines either one way or the other; but it would be preferable to make a third

group for these, viz. III. *Mediogastric*, in which the siphuncle is near the centre. These groups suffice admirably for the Silurian forms, which are all more or less unornamented; but possibly a fourth group of *Ornati* should be distinguished, when we include the later Palæozoic forms.

Subgenera.—1. TRIGONOCERAS.—The only peculiarity of this is its triangular section with inflated edges, with which the ornaments are more or less in relation. It appears to be confined to Carboniferous rocks.

2. PILOCERAS ?—The remarkable fossils found in the Durness Limestone, and described by Mr. Salter under this title, were considered by him to be complete shells in which the septa and siphuncle were united into conical sheaths, and thus to offer the simplest of Cephalopod forms. The absence, however, of a siphuncle on this interpretation, destroys the only reason for calling the fossil cephalopodous at all; since many Gastropods, e.g. *Euomphalus*, have septa-like partitions. At a later date ('Pal. Foss.' 1865), Mr. Billings described some Canadian fossils, in which an undoubted siphuncle of large size, in relation to septa preserved around it, showed, in its interior, conical sheaths like those of Salter's *Piloceras*, with the exception that they were straight and not so rapidly increasing. As he named these specimens *Piloceras*, it is evident that he considered the Scotch fossils as siphuncles only, the septa being absent, and this view has been adopted by Barrande. If this be the correct view, these forms might well be placed as a subgenus of *Cyrtoceras*, characterised by the presence of sheaths within the siphuncle, and corresponding to *Endoceras* among the *Orthocerata*. No septa have, however, been ever found associated with them at Durness; though this is less remarkable, on account of the extreme rarity of septa associated with the siphuncles of *Actinoceras* at Lake Huron; on the other hand, the fossils themselves bear a close resemblance to the opercula of the *Maclurea*, found associated with them. This genus is supposed to be a Gastropod on account of the absence of any hinge between its valves; but its operculum is singularly like the upper valve of a Radiolite, whose hinge is, to say the least, a peculiar one; while an allied form from newer rocks, *Caprinella*, has very similar partitions to those of *Piloceras*. It is possible, therefore, that *Piloceras* may form part of a group which should unite *Maclurea* with the *Rudistes*, and thus be removed from the Cephalopoda altogether.

Range.—The genus *Cyrtoceras* commenced in the Tremadoc rocks, and has abundant representatives throughout the Silurian, Devonian, and Carboniferous, in all fossiliferous localities; though the maximum of described forms occurs in the Silurian, and there is but one species recorded from Permian rocks in Kansas. Of the subgenera, *Piloceras* is of Lower Silurian, and *Trigonoceras* of Carboniferous age.

GROUP II. INFLATI.

Genus POTERIOCERAS, M'Coy.

1844. POTERIOCERAS, M'Coy, 'Syn. Carb. Foss. Ireland.'
1847. ONCOCERAS, Hall, 'Pal. New York,' vol. i.

History.—M'Coy first gave this name to certain Carboniferous fossils which he defined as "fusiform, short; mouth contracted; siphuncle dilated between the chambers, excentric;" and he gave a diagram, not justified by any known specimen, representing the aperture as very small but simple. He refers to *Gomphoceras* as having been given to a "fusiform species," and objects to that name, on the ground of its having been adopted for a genus of insects. If that were the only objection to it, the earlier names of *Bolboceras* and *Apioceras*, proposed by F. de Waldheim, on the same ground would have priority; but the only species described by M'Coy, as well as his diagram, indicates a genus with the form of a *Gomphoceras* without its peculiar aperture. The name has been considered by Barrande and others as a mere synonym for *Gomphoceras*, while the species described has been relegated to *Orthoceras.* Professor Hall founded the genus *Oncoceras*, for shells resembling the *Phragmoceras* in every respect, except that they have a dorsal siphuncle instead of the usual ventral one; but this is not a good generic character, and his actual type, as well as others which have been referred to the genus, differ in no respect from M'Coy's genus.

Description.—The general shape is more or less that of a butt or vase, the earlier part being not certainly known; in some cases, however, the septal portion is very like that of an *Orthoceras*, but an inflation commencing at or before the body-chamber is the essential character of the genus. The aperture is simple and often oblique, in the contrary direction to the septa. There are seldom, if ever, any ornaments; the siphuncle is usually bulbous, but neither its position nor character is essential. The septa are mostly approximate. The shell commonly shows structural marks, such as normal lines, &c. The genus might possibly be divided into *Longicones* and *Brevicones*, like the *Orthocerata*, but the number of species is too small to make it worth while to group them.

Range.—This genus, as at present defined, appears sporadically in the Lower Silurian and in the Carboniferous. In the first it has been called *Oncoceras*, and perhaps its sporadic appearance might be held to justify the separation of the two groups as distinct genera.

Genus GOMPHOCERAS, Sowerby.

1839. GOMPHOCERAS, Sowerby, in Murchison's 'Silurian System.'
1844. BOLBOCERAS, APIOCERAS, F. de Waldheim, 'Bull. S. N. Moscow.'
1854. SYCOCERAS, Pictet, 'Traité de Paléontologie.'
1877. MESOCERAS, Barrande, 'Système Sil. de Bohême' [=subgenus].

History.—The genus was first established by Sowerby for the Silurian shells with a pyriform shape and a contracted aperture, and was considered as intermediate between *Orthoceras* and *Phragmoceras.* It has been generally accepted; the names proposed by F. de Waldheim being suggested merely by the similarity of Sowerby's name to that of a genus of insects. Pictet's genus is founded on the marginal position of the siphuncle—a feature which, it has been shown, cannot be allowed generic importance among the Nautiloids.

Description.—The general form is butt-shaped, the main axis being essentially straight; nevertheless one side is not always similar to the other, and when one is more convex we are led towards the curvature of the *Phragmoceras.* The earlier parts of the shell are almost unknown; only one specimen—the type—showing a narrower commencement than usual, and indicating that the apex, if ever preserved, might have the form of a brevicone *Orthoceras* (such as that called *O. xit*). The shell is thick, and has very superficial ornaments, seldom preserved; but there are often crenulations at the base of the body-chamber, and feebly-marked structural lines. The section is never far from round, and may be transverse. The body-chamber occupies nearly half the shell as commonly preserved. The aperture consists essentially of a larger and a smaller opening, with a more or less narrow one between them. The smaller, which is considered to characterise the ventral side of the animal, and which corresponds to the backward sinus of the ornaments when these are present, is always simple; but the larger, in many species, is festooned by from two to seven lobes, which furnish admirable specific characters. The shell is often thickened round the aperture. The septa are approximate and direct, and have usually very little convexity. The siphuncle is seldom marginal, but may be so; it is most usually near the centre, but towards the more convex side. It may be cylindrical or inflated. The chief differences between *Gomphoceras* and *Phragmoceras* are its straightness, its want of ornament, and its more commonly exogastric or mediogastric siphuncle.

Subgenus MESOCERAS.—This form differs from the ordinary type in having its aperture transverse instead of longitudinal, and not divided into two portions, but forming a broad curved band.

Range.—It is doubtful if the genus *Gomphoceras* occurs anywhere out of the

Upper Silurian rocks, none of those recorded from elsewhere having a complicated aperture preserved, and several belonging certainly to other genera.

Genus Phragmoceras, Sowerby.

1839. Phragmoceras, Sowerby in Murchison's 'Silurian System.'

History.—This genus was established by Sowerby at the same time as *Gomphoceras*, and he states that the name was suggested to him by Broderip, and this accounts for the genus being quoted as the creation of the latter, who was neither its describer nor author. Another name applied to some of its species is *Campulites*, which M. Deshayes gave to endogastric forms of all kinds, whether of *Cyrtocerata* or *Phragmocerata*, and which may therefore be a synonym of either.

Description.—The curvature is always well marked, but is never very great; the section usually has its longer diameter in the plane of curvature. The body-chamber is less inflated than in *Gomphoceras*, especially on the concave side; the aperture is on the same type,—namely, two larger openings connected by a narrower passage, the larger one often lobated, the lobes being of an even number in all the known species. There are very often feeble transverse ribs, which undulate sigmoidally across the shell. The septa are usually approximate, and have very little convexity; the earlier ones do not so constantly fall off as in *Gomphoceras*. The siphuncle in the great majority of species is internal, hence these might be called endogastric; there are, however, a few both of mediogastric and exogastric species, but these are not worth separating, either as divisions or as subgenera: the elements of the siphuncle are usually, but not universally, nummuloid. There are, in some species, crenulations at the base of the body-chamber.

Divisions.—Besides the general subdivision relating to the position of the siphuncle, it is to be noted that Barrande makes groups of the species according to the number of lobes in the larger opening of the aperture—calling them *Dimeres*, *Tetrameres*, &c.

Range.—The genus *Phragmoceras* has three representatives in the Lower Silurian rocks of England, Bohemia, and Canada, but it is otherwise confined to the Upper Silurian. The Carboniferous species referred to it have been founded on errors. It is chiefly found in England and Bohemia, and there are a few in Germany, America, and Canada.

Genus ASCOCERAS, Barrande.

1846. CRYPTOCERAS, Barrande, 'Not. Prél. Syst. Sil. Bohême.' (Not D'Orbigny.)
1847. ASCOCERAS, Barrande, 'Oesterr. Blätt. f. Litt.' &c., and 'Bull. Soc. Géol. de France,' 2nd ser. vol. xii.
1865. APHRAGMITES, Barrande, 'Syst. Sil. de Bohême.'
— GLOSSOCERAS, Barrande, 'Syst. Sil. de Bohême' [=subgenus].

History.—The remarkable form so well known under the above generic title was first discovered by Barrande in Bohemia. He regarded it as the most simple of the Nautiloid Cephalopoda, and looked upon the portion of the body-chamber which lies beside the distorted septa as a representative of the siphuncle. He hence compared the genus to the *Vaginati*, and regarded it as more simple than they. At the same time he recognised the existence of the small chambers below the body-chamber with the mark of a siphuncle in the centre. The character of the siphuncle was thus regarded as changing with age. The usual absence of any of the ordinary septal portion of the shell has led palæontologists to regard the part preserved as the complete shell; and the septa being seen on the side, the most extraordinary definition has been given of the genus, such as "shell bent upon itself, as in *Ptychoceras*." The so-called genus *Aphragmites* was founded for those shells which agreed with *Ascoceras* in every particular, *except* that there were no sigmoid septa. Most examples of *Ascoceras* show no peculiarity about the aperture, but in certain species are found tongue-like projections on the dorsal side, corresponding to a sinus on the ventral side, and for these the name *Glossoceras* has been proposed. The two genera thus become representatives of the two series into which Barrande divides the Nautiloids,—those with simple and those with contracted apertures. Seeing, however, that the ventral sinus is present in *Ascoceras*, and in only *some* referred to *Glossoceras* can any tongue-like process be found, it would appear that these forms are not worthy of more than subgeneric distinction. As regards the name *Cryptoceras*, it was the first proposed, but was afterwards rejected in favour of the present one.

Description.—The true nature of the *Ascoceras* appears to have been completely misunderstood. It is by no means the simplest form of Cephalopod, but the most abnormal. Its interpretation may be best arrived at by a study of the beautiful example figured by Barrande ('Syst. Sil. de Bohême,' vol. ii. Pl. 513) and the surface indications on English specimens. It is thus seen that the parts preserved do not form *two* sets of septa, and *two* forms of siphuncle; but that the curious sigmoid septa are parts only of the others which are so constantly hidden. On examining Barrande's section, it is seen that the hidden septa are separate from each other on the side remote from the sigmoids, and join the siphuncle by well-marked necks. The corresponding septa on the sigmoid side all pass by gentle and unbroken curves

into the single band which joins the hidden to the sigmoid portions; but this band examined on English specimens is found to be not really simple, but multiple, consisting of several coalesced septa. In Barrande's figure there are four hidden septa on the remote side; but five are drawn on the nearer side to the sigmoids, which latter are also four in number. Probably the fifth of the nearer septa is a mistake, as it has no properly formed neck. Thus the number of the sigmoid lines corresponds to that of the hidden septa, and affords a further proof of the correctness of the present interpretation. The smaller parts of the septa do not appear to be lost to view by falling off, as has been supposed, the caducous ones being of an ordinary character, but they are hidden within the specimens, and are either not seen for want of cutting, or, when the siphuncle is very near the side, are too obscure to be observed. Another specimen figured by Barrande (Pl. 93) shows this admirably; one side of it has the ordinary septal surface well exhibited, and the other, or cut side, has the smaller hidden parts of the sigmoid septa very obviously run up into one mass with a wide siphuncle.

It is now, therefore, possible to describe *Ascoceras* in the ordinary way. The earlier part is unknown, the body-chamber and the last few septal chambers only being preserved in association. The section varies from elliptical to round. The body-chamber is inflated, and gradually retracts to a neck-like prolongation, the dorsal part of which is produced, and forms in some a tongue-like process (*Glossoceras*). The ornaments are transverse, and consist either of ribs or of finer lines. The earlier septa are of the ordinary kind, with very little convexity, and the siphuncle excentric, in some of large size; though its cavity may be more or less obliterated by a later overgrowth of shell, and it appears to diminish rapidly in size at last. The last few chambers are distorted, and their dorsal portions are seldom seen: on the dorsal side of the siphuncle the septa are distinct as usual; but on the ventral side they soon coalesce into a single septum, and separate again to form sigmoid partitions, encroaching on the side of the body-chamber. In some examples these sigmoid portions of the septa are not developed (*Aphragmites*).

Subgenus GLOSSOCERAS.—The dorsal side is produced into a long tongue-shaped process, almost dividing the aperture into two lateral portions; the body-chamber is very little inflated.

Range.—This genus is confined to the Upper Silurian rocks, in which it has been met with in England, Bohemia, and America.

Group III. Spirales.

Genus Nautilus, antiquorum.

1732. Nautilus, Breyn, 'Diss. Phys. de Polythalamiis.'
1808. Bisiphites, Montfort, 'Conchyl. Système.'
1832. Clymenia, Münster, 'Beiträge zur Petrefactenkunde' [= subgenus].
1835. Aturia, Bronn, 'Lethæa Geognostica' [= subgenus].
1838. Trocholites, Conrad, 'Ann. Geol. Report.'
1844. Temnocheilus, M'Coy, 'Syn. Carb. Foss. Ireland.'
— Discites, „ „ „ [= subgenus].
1850. Cryptoceras (part), D'Orbigny, 'Cours de Pal. stratigraphique.'
1856. Nothoceras, Barrande, 'Bull. Soc. Géol. France' [= subgenus].
1861. Trematodiscus, Meek & Worthen, 'Proc. Acad. Soc. Philadelphia.'
1865. Hercoceras, Barrande, 'Défense des Colonies.'

History.—It is certain that both the shells which have been called *Nautilus* were known to Aristotle; namely, that which is now called by the same name in Zoology, the "Pearly Nautilus," and that which has become the "Argonaut" or "Paper Nautilus." Breyn, to whom we may look as the earliest systematic writer on Cephalopods, made this a genus, and the work of subsequent authors has been to subdivide it into groups, which may be called genera or subgenera according to taste. The *Bisiphites* of Montfort was merely an example which showed clearly the usual small dorsal lobe in the septum, which was mistaken for a second siphuncle. The subgenus *Clymenia*, founded by Münster, has the best claims for generic rank, by its open whorls, its siphuncle within the dorsal lobe, and its sometimes angular sutures; it is only the combination, however, of these characters that is peculiar. Each may separately be matched in other groups. The tertiary *Aturia* of Bronn is merely an involute *Clymenia*, showing the close connection of both with *Nautilus* proper. *Trocholites* was founded in 1838 by Conrad in an inaccessible journal, but obtained currency by Hall's description and figures in the 'Palæontology of New York;' it is merely a *Nautilus*, in which the siphuncle is contained within the dorsal lobe. M'Coy, in 1844, proposed two subdivisions of the genus for Carboniferous fossils: the first, *Temnocheilus*, being merely those whose apertures were well enough preserved to show their sigmoid outline; the second, *Discites*, was with more reason adopted for open-whorled species, of which those with angular sections were afterwards called *Trematodiscus* by Meek and Worthen. D'Orbigny created the genus *Cryptoceras*, for the *Nautili* with external siphuncles found in the Carboniferous rocks. Barrande gave the name *Hercoceras* to certain forms, of which some belong to *Nautilus*, characterised by a shelly deposit in the region of the hood

in the living animal; and *Nothoceras*, for a single species in which the septum has its "neck" reversed.

Description.—The shell is discoidal, and the whorls are in contact throughout. There is often, however, a vacuity in the centre, so that until a complete whorl is formed the shell might be taken for a *Cyrtoceras* or *Gyroceras*. The whorls usually overlap, and some species are quite involute; but in others, placed in distinct subgenera, the whorls are only just in contact. Most have no ornaments, but the open-whorled ones may have longitudinal bands or tubercles, or finer riblets and striæ. The aperture is bounded by a sigmoid curve which is more or less pronounced, but which has no processes, except on the dorsal side in a few: hence called *Hercoceras*. The septa are concave towards the aperture, and the sutures are slightly sigmoid; but in some they are thrown into deep folds, which in certain cases even become angular. There is always a small dorsal lobe, and the neck of the siphuncle is turned away from the aperture, except in the peculiar form called *Nothoceras*. The septal surfaces usually have considerable convexity in involute species, but in the more open ones there is scarcely any in the transverse direction. The septa are seldom either very remote or very approximate. The siphuncle occupies all positions, from the ventral side to the dorsal, in which latter case it lies within the dorsal lobe, which is made deeper by the coalescence of the neck, the species showing this being classed as distinct subgenera, *Clymenia*, *Aturia*, and *Trocholites*; the most common position is towards the centre. The elements of the siphuncle are almost always cylindrical. Epidermids are constantly present on the body-chambers of the Carboniferous *Nautili*, and the septal surface of the recent species is covered with vascular marks, and a normal line is very common.

Subdivisions.—Many attempts at subdividing this genus into groups have been made. The earliest was that of Quenstedt, who proposed the following ('De Notis Nautilearum Primariis'):—

1. *Imperfecti*—for those with an open centre.
2. *Clymeniæ simplices*—*Clymenias* with simple sutures.
3. *Clymeniæ angulosæ*—*Clymenias* with angular sutures.
4. *Moniliferi*—with nummuloid siphuncles (in the Trias only).
5. *Bisiphites*—with a well-marked dorsal lobe.
6. *Simplices*—the ordinary forms with simple sutures.
7. *Undulati*—with sigmoidal ornaments forming a sinus on the convex side.
8. *Aganides*—with sigmoidal sutures, like *Aturia*.

The assemblage of forms thus classed includes several subgenera; but D'Orbigny's subdivisions ('Pal. Franc. Terr. Jur.') refer only to the ordinary *Nautili* of the Secondary rocks, which he names:—

1. *Striati*, if with fine ornaments; 2. *Radiati*, if with ribs; 3. or *Lævigati*, if without ornaments.

De Koninck ('Terr. Carb. de Belg.') combines parts of these two classifications, making the following groups :—1. *Imperfecti*; 2. *Striati*; 3. *Radiati*; 4. *Lævigati*; 5. *Clymeniæ simplices*; 6. *Clymeniæ angulatæ*;—the definitions remaining as above.

Setting aside those species which may be conveniently formed into subgenera, the following divisions are suggested as most useful :—

1. *Simplices*—of the ordinary form, with or without striated surfaces, including *Trocholites*.

2. *Radiati*—with radiating, sigmoidal, or angular ribs.

3. *Ornati*—with ornaments of various kinds, such as tubercles, mostly found in the Carboniferous rocks, equivalent to part of M'Coy's subgenus *Temnocheilus*.

4. *Sinuosi*—with sinuous sutures.

5. *Moniliferi*—with a nummuloid siphuncle, found in the Trias only.

Subgenera.—1. Trocholites.—This has the siphuncle within the dorsal lobe; but otherwise like one of the *Simplices*.

2. Clymenia.—Whorls uncovered, siphuncle within the dorsal lobe, sutures undulating or angular. This group, so eminently characteristic of the Trias, is the most worthy of distinction, especially when the sutures are angular. Yet its internal siphuncle may be matched in *Trocholites*, its sutures in *Nautilus sinuatus*, and its open whorls in *Discites*.

3. Aturia.—This only differs from *Clymenia* in being involute like an ordinary *Nautilus*, thus diminishing the distance between the two latter forms. It is confined to Tertiary rocks.

4. Discites.—In these the whorls are uncovered and usually ornamented in a longitudinal direction. There is a central vacuity, which may have as much as one-third the diameter of the shell. This subgenus constituted the *Imperfecti* of Quenstedt, but is quite worthy of a distinct title. It is confined to the Carboniferous rocks.

5. Nothoceras.—The peculiarities of the siphuncle—which possesses radiating longitudinal lamellæ, lies on the convex side of the shell, and is joined to the septa by a neck which turns towards, instead of away from, the mouth—are ample justification for using a distinct title, even if it be not allowed a generic value.

Range.—The genus *Nautilus* appears first in the New World and England, eleven species having been recorded from the Lower Silurian of Newfoundland and Canada, and three from our own country, of the subgenus *Trocholites*. The Upper Silurian species on the contrary, found rarely in England, are most abundant in Bohemia, though few in number even there, including the subgenus *Nothoceras*. In its typical form it is almost wanting in the Devonian rocks, having but seven representatives at the most; but the subgenus *Clymenia* is largely developed, and is confined to these rocks. The genus suddenly expands to a maximum in the Carboniferous and develops the subgenus *Discites*. It almost dies away in the Permian, having only five species, of which three are American. In the Secondary and Tertiary rocks it

is uniformly, though not abundantly represented, throwing out the subgenus *Aturia* in Eocene times, when it was pretty uniformly distributed over the temperate zones, but it is now strictly confined to the Tropics, is chiefly found in the Malay Archipelago, and affords the only living representatives of the Tetrabranchiate group.

Genus Gyroceras, De Koninck.

1844. Gyroceras, De Koninck, 'Terr. Carb. de Belgique.'
1846. Spirulites, Quenstedt, 'Cephalopoda.'
1850. Nautiloceras, D'Orbigny, 'Cours de Pal. stratigraphique.'

History.—The name *Gyroceratites* appears to have been first used by Von Meyer, for fossils which turned out to be Goniatites, while the true *Gyrocerata* were referred to *Spirula.* De Koninck's name, however, for the evolute Nautiloids has gained general acceptance. D'Orbigny alone has attempted to dismember it, restricting the original name to those with an external siphuncle, and proposing *Nautiloceras* for those with a central one. This, however, is a non-generic character, and the group remains unique.

Description.—The shell is curved in one plane, and makes at least a complete whorl; but the whorls are out of contact. The section is more or less rounded, and tends to be transverse. The aperture is usually simple, but occasionally has expansions of shell on either side. The ornaments are often complex, consisting of nodes and ribs, but in some they are absent. The septa are very simple, as in an ordinary *Nautilus.* The siphuncle may occupy any position, external, central, or internal, the first position being the ordinary one. No structural marks have been observed. There are no subdivisions to note.

Range.—The *Gyrocerata* are confined in Britain to the Devonian rocks; but they are said to be found in the Lower Silurian of Canada, in the Upper Silurian of Bohemia, and the United States, and they extend to the Carboniferous rocks in Belgium.

Group IV. Irregulares.

Genus Trochoceras, Barrande.

1848. Trochoceras, Barrande, 'Haiding. Berichte,' iii. iv.
Lituites, auctorum Anglicorum.

History.—The genus has been so little known that since its establishment by Barrande nothing has been done beyond the reference of some species to it which were formerly called *Lituites,* and the description of some new forms.

Description.—The essential character of the genus is the want of symmetry of its

spire, which, however, in most cases is so slight that it has to a great extent passed unnoticed. This asymmetry is so unusual a feature among Cephalopods that it has been used as a generic bond to unite species which would otherwise have been placed in distinct genera, from the whorls in some being in, and in others out of, contact. The whorls are usually few in number; and the commencement of the shell being relatively large, there is no central vacuity in the coil. The whorls are relatively narrow, and the later do not conceal the earlier ones. The section may be nearly circular, elliptic, subquadrate, or sublanceolate, but is very seldom, if ever, transverse. The ornaments are various, but in the majority consist of transverse ribs adorned by parallel riblets; several species appear to have been smooth. The body-chamber is comparatively short, but in some species the uniform curvature is not continued to the aperture, but the body-chamber more or less leaves the whorls. The aperture is usually simple, but the sides may be more or less pressed inwards so as to give a pseudo-complex appearance to it. The septa are rather approximate, and have but little transverse convexity. The siphuncle is mostly simple and external, but when the septa are very close its elements appear beaded. Epidermids are not rare on the internal casts.

The shells referable to this genus have been for the most part called *Lituites*, and when part of the last whorl leaves the rest they certainly approach very closely to that genus; and if also the whorls are out of contact, the only difference is the want of symmetry.

Divisions.—Barrande divides the genus into endogastric and exogastric groups, but there is only one Bohemian species in the former, and not a single British one.

Range.—There are several American and Swedish Lower Silurian species of *Trochoceras* which are called *Lituites*, and the genus is found in Britain in rocks of the same age; nevertheless the genus is chiefly an Upper Silurian one, abundant in Bohemia, England, and the United States, while two species only have been described from the Devonian in Nassau and France.

Genus LITUITES, Breyn.

1732. LITUITES, Breyn, 'Dissert. Phys. de Polythalamiis.'
1808. LITUITES, HORTOLUS, Montfort, 'Conchyl. System,' vol. i.

History.—Breyn's definition of the genus was that its base was in a straight line, but its commencement a symmetrical unconcealed spire in one plane. He did not, however, distinguish between those with the whorls in contact and those in which they were disconnected, but the species described was of the latter kind. Montfort, reproducing the general definition of *Lituites*, introduced the name *Hortolus* for those with disconnected whorls. Since that time the name *Lituites* has been the receptacle for all coiled forms from Silurian rocks, whether provided with a straight

portion or not. This latter character, however, being the essential one of the genus, such references are unjustifiable. Since the creation of the genus *Trochoceras*, all that are at all unsymmetrical find a place; though some, like our own *T. giganteum*, have a short piece that is straight. With regard to the question of the whorls being in or out of contact, I have not been able to find any figure representing a true *Lituites* with whorls *in* contact, except the rough one of Montfort, and all the fragments which have been figured under the name of "imperfecti" belong, to judge by the drawings, either to *Trochoceras*, *Nautilus*, or *Ophidioceras*. There does not appear to be a single true *Lituites* in Bohemia, the fragment so called by Barrande having no straight piece, and the whorls are in contact; unless the species called *Trochoceras arietinum* belong to the genus, which in fact seems a rare one.

Description.—The early part of the shell is coiled, but the whorls are out of contact, so far as known; later on, the curvature is lost or changed, and the shell continues in a straight direction, but always with more or less of an irregular curve. The section is not far from circular, and the rate of increase slow. The body-chamber occupies a portion only of the straight piece. The ornaments are usually transverse and the siphuncle central, the sutures being simple. The aperture has been described as having two lappets, which bend inwards; but these do not appear to have been observed on a complete shell. The size, including the straight piece, is several inches.

Range.—The genus is confined to the Silurian rocks, there being one species in Sweden, in the Lower Silurian, one in the Upper Silurian of Britain, and perhaps another, which is found also in Bohemia.

Genus OPHIDIOCERAS, Barrande.

1865. OPHIOCERAS, Barrande, 'Syst. Sil. de Bohême,' plates, vol. ii.
1867. OPHIDIOCERAS, Barrande, loc. cit., text, vol. ii.

History.—This was established by Barrande, as a subgenus of *Lituites*, for the species with a short "crosse" or straight piece.

Description.—The forms figured by Barrande have a very peculiar aspect, and show generic characters very distinct from the *Lituites*. The shell is quite symmetrical, and the whorls, except at last, accurately in contact, with very little, or no, central vacuity. The rate of increase is very small. The section is more or less rounded, but has a flat band running along the convex side. The last portion, which would make about a quarter whorl, or more, is continued in a straight line, and the termination is marked by an inflation of the shell previous to its contracting, so as to form a trifid aperture. The ornaments are transverse in all known species, and the siphuncle subcentral; the sutures are simple. They are all of small size, not exceeding two inches in diameter.

This seems to me a very well-marked group of small shells, whose collective characters form as good a generic distinction as any that could be desired. The band along the convex side is universal in all well-preserved species, and is probably essential to the genus. If species without this band and with a well-preserved simple aperture were found, they would form the link to the genus *Lituites*, which is at present but remotely related.

Range.—The genus is only known at present in the Upper Silurian rocks of England and Bohemia, unless the species described by Barrande as a *Lituites* from the Lower Silurian belongs here.

Genus CRYPTOCERAS, D'Orbigny.

1850. CRYPTOCERAS, D'Orbigny, 'Cours de Pal. stratigraphique.'

History.—This genus was separated from *Nautilus*, according to D'Orbigny's general scheme of subdivision, on account of the position of the siphuncle, the present name being ascribed to those in which that organ is external. This character alone being insufficient for distinction, the name has met with little acceptance, but it may be used, as below, to represent a genus typified by the species to which D'Orbigny chiefly referred, i.e. *Nautilus dorsalis.*

Description.—The whorls are few and not always in contact, and there is an initial vacuity. The curvature is not continuous, but in the region of the body-chamber, which is also transversely inflated, it diminishes to almost zero, but increases again afterwards. The siphuncle is only known as external, but this may not be essential. The shell is thus, as it were, a *Poterioceras*, with the curvature of an *Ancycloceras.*

Range.—It is not certain if there be any other representative of the genus than the typical Carboniferous species, unless the so-called *Cyrtoceras bdellalites* of the Devonian belongs to it.

BIBLIOGRAPHY OF BRITISH SILURIAN CEPHALOPODS.

1814.—The first Cephalopod figured or described from British Silurian rocks was that named *Orthoceras circulare* by SOWERBY, in the 'Mineral Conchology' (Pl. 60), from Dudley.

1818.—The next is described in the same work (Pl. 133). It is *Orthoceras annulatum*, from the limestone of Coalbrookdale, supposed at the time to be Carboniferous, but now known to be Silurian.

1839.—The Silurian system by R. I. MURCHISON is, however, the starting-point for the great majority of the species. In the second part, or description of the organic remains, by SOWERBY, the following are introduced:—From the Tilestones are *Orthoceras semipartitum* and *O. tracheale*. From the Upper Ludlow, *Orthoceras striatum*, *virgatum*, *ibex*, *articulatum*; also *Cyrtoceras læve*, since recognised as an *Ecculiomphalus*. From the Aymestry Limestone, *O. mocktreense*, *pyriforme*, *virgatum*. From the Lower Ludlow, *O. ludense*, *gregarium*, *distans*, *excentricum*, *imbricatum*, *filosum*, *virgatum*, *dimidiatum*, *fimbriatum*, *ibex*, and *pyriforme*, as well as the previously described *O. annulatum* and the so-called *Cyrtoceras læve*; also *Phragmoceras arcuatum*, *ventricosum*, *compressum*, and *nautileum*, the genus being at the same time introduced and defined, the name being suggested to him by Broderip; also *Lituites articulatus*, *giganteus*, and *tortuosus*. From the Wenlock Limestone are described *Orthoceras Brightii*, *annulatum*, *pyriforme*, and *Lituites Biddulphii* and *giganteus*. From the Wenlock Shale, *O. excentricum*, *nummularium*, *attenuatum*, *virgatum*, *canaliculatum*, *fimbriatum*, and *annulatum*. And from the Lower Silurian rocks, *O. annulatum*, *approximatum*, *bisiphonatum*; *Nautilus undosus*, and *Lituites cornu-arietis*. The genus *Gomphoceras* is also suggested for some species named *Phragmoceras*, but having their axis straight. Only a portion of these names are still accepted.

1843.—PORTLOCK, 'Report on the Geology of the County of Londonderry, and of parts of Tyrone and Fermanagh.' In his descriptive list of fossils he enumerates many Cephalopods. Some he refers to Münster's Devonian species, as *Orthoceras calamiteum*, *subannulare*, *subflexuosum*, *irregulare*, *regulare*; *Gomphoceras subpyriforme* and *subfusiforme*, and *Phragmoceras Brateri*. A few he quotes from Sowerby, including *O. tubicinella*, originally described from the Devonian, to which he adds a variety, *subnodosum*. He records *Phragmoceras arcuatum* and *compressum*, *Lituites cornu-arietis*, *Orthoceras Brongniartii* (Troost) and *lineatum* (Hisinger), but the rest he considers new, assigning the following names:—*Orthoceras gracile*, *perannulatum*, *pomeroense*, *subcostatum*, *tenuicinctum*, *elongato-cinctum*, *subundulatum*, *tumidum*, *brevi-conicum*, *subarcuatum*, *complanato-septum*, *incertum*, and *Phragmoceras inæquiseptum*.

He also describes a Theca as *Orthoceras triangulare;* and founds a new genus, *Koleoceras,* for certain *Orthocerata,* with some spongeous or hydroid overgrowth, which he believed to be part of their organisation. The species ranged under this generic title, *pseudo-regulare, pseudo-speciosum,* and *Ballii,* can all be placed among those named above. The larger number of his specimens are very fragmentary, and comparatively few of his names are now of value.

1844.—R. GRIFFITHS, in the 'Report of the British Association for 1843,' in a paper "On the Red Sandstone, Devonian, and Silurian districts of Ireland," records *Orthoceras imbricatum* (Wahl.), from Egool.

1845.—In the Report of the same Association for 1844, in a paper "On certain Silurian districts in Ireland," the same author records *O. gregarium, tenuicinctum, virgatum,* and *filosum,* from Ballinahinch, Tonlegee, and Tullyconnor.

1845.—SEDGWICK, "On the older Palæozoic (Protozoic) Rocks of North Wales," Quart. Journ. Geol. Soc., vol. i. p. 5. SALTER supplies the list of fossils, and records, without describing, *Nautilus primævus,* subsequently recognised by the same author as *Trocholites planorbiformis* (Conrad); also *Lituites cornu-arietis,* from the Bala Beds.

1845.—FORBES, "On Two Species of Creseis? collected by Prof. Sedgwick," Quart. Journ. Geol. Soc., vol. i. p. 145. These are named *C. primæva* and *C. Sedgwickii.* They have subsequently been ascertained to be *Orthocerata,* and the former to be new. They are from the Upper Silurian.

1845.—SEDGWICK, "On the comparative Classification of the fossiliferous Strata of North Wales, and the corresponding Deposits of Cumberland, Westmoreland, and Lancashire," Quart. Journ. Geol. Soc., vol. i. p. 445. In this are recorded *Lituites cornu-arietis* from the Coniston Limestone, and *Orthoceras ibex* from the Ireleth Slates.

1846.—SHARPE, "Contributions to the Geology of North Wales," Quart. Journ. Geol. Soc., vol. ii. p. 283. In Pl. 13, figs. 2, 3, he figures *Creseis primæva* (Forbes), and *C. ventricosa,* from Upper Silurian. Both these have been subsequently recognised to be *Orthocerata.*

1846.—M'COY, 'A Synopsis of the Silurian Fossils of Ireland.' In this work the *Orthocerata,* thought to be identified with previously described ones, are referred to under the names of *Orthoceras acuarium* (Münst.), *approximatum* (Sow.), *breviconicum* (Portl.), *bullatum* (Sow.), *elongatocinctum* (Portl.), *filosum* (Sow.), *gregarium* (Sow.), *ibex* (Sow.), *imbricatum* (Wahl.), *lineare* (Münst.), *lineatum* (His.), *regulare* (Schl.), *semipartitum* (Sow.), *striato-punctatum* (Münst.), *subundulatum* (Portl.), *tenuicinctum* (Portl.), *tumidum* (Portl.). The localities of these species are given, but not their geological position. How far the names here given can be adopted, will be seen in the present work. M'Coy also describes as new species *Orthoceras coralliforme* (Pl. I. fig. 3) from co. Galway, *O. subgregarium* (fig. 4) from Leenane, and *Poterioceras approximatum* (fig. 5) from Tyrone. The last-named genus had already been established by M'Coy, in his 'Synopsis of the Carboniferous Fossils of Ireland.'

He proves in the work under notice that the *Koleoceras* of Portlock is formed by a parasite which he thinks allied to *Halichondria*; in the case of *Koleoceras Ballii* it is actually not growing on a Cephalopod at all, but on a *Murchisonia*. He also records a number of Bellerophons as Cephalopods allied to the Argonaut.

1848.—'Memoirs of the Geological Survey of Great Britain,' vol. ii. part i. This is a memoir by Prof. J. Phillips on "The Malvern Hills compared with the Palæozoic districts of Abberley, &c." In it are recorded the localities of numerous Cephalopods previously described, and in the appendix by J. PHILLIPS and J. W. SALTER descriptions are given of *Lituites undosus* (Sow.) and *Orthoceras Brightii* (Sow.); while the first-named author figures and describes as new *O. marloense* (Pl. XIII. fig. 1) and *O. textile* (figs. 5, 6), and the last-named describes *O. perelegans* (figs. 2, 3, 4), and makes some remarks on the characters of the genus *Lituites*.

1849.—SALTER, in a paper by Mr. Sharpe, "On the Geology of the Neighbourhood of Oporto, including the Silurian Coal and Slates of Vallongo," Quart. Journ. Geol. Soc., vol. v. p. 142, founds the species *Orthoceras vagans*, and figures it from Spanish specimens, but states at the same time that it is abundant in the Lower Silurian rocks of Wales and Westmoreland.

1849.—D'ORBIGNY, 'Prodrome de Paléontologie stratigraphique.' He separates *Lituites cornu-arietis*, var. (β) of Sowerby, from var. (α), under the name of *L. Sowerbianus*. He gives the name of *Orthoceras subconicum* to the species described by Sowerby in the Silurian system as *O. conicum*, the name being pre-occupied by Hisinger; that of *O. subdimidiatum* to the *O. dimidiatum* of Sowerby, the name being pre-occupied by Münster; that of *O. subattenuatum* to the *O. attenuatum* of Sowerby, the name being pre-occupied by Fleming.

1851.—M'COY, "On some new Silurian Mollusca," Annals and Mag. of Nat. Hist., Ser. II., vol. vii. p. 45. The author separates one of the figures (fig. 19) of Sowerby's *Gomphoceras pyriforme* as *Poterioceras ellipticum*, and one of *Phragmoceras arcuatum* (fig. 1) as *P. intermedium*. He also describes as new *Cycloceras tenuiannulatum* from the Upper Silurian, and *Orthoceras politum* from the Lower Silurian. *Cycloceras* was founded as a subgenus in his 'Synopsis of the Carboniferous Fossils of Ireland.'

1851.—HARKNESS, "On the Silurian Rocks of Dumfriesshire and Kirkcudbrightshire," Quart. Journ. Geol. Soc., vol. vii. p. 46, records *Orthoceras Sedgwickii*, *annulatum*, and *tenuicinctum*, from Kirkcudbrightshire.

1851.—SALTER, in a paper by Murchison, "On the Silurian Rocks of the South of Scotland," Quart. Journ. Geol. Soc., vol. vii. p. 137, gives a figure and description of a new species—*Orthoceras Barrandei*; also figures of *O. politum* (M'Coy) and *O. vaginatum* (Schl.), and records in addition *O. angulatum* (Wahl.) and *O. calamiteum* (Münst.).

1851.—SEDGWICK, "On the Geological Structure and Relations of the Frontier

Chain of Scotland," Brit. Ass. Rep. for 1850, p. 103. In this M'Coy records *Orthoceras anellatum* (misprint for *anellum*) (Hall) and *O. politum*, from Girvan. The former is not referred to again by M'Coy in later writings, and is probably given up as British.

1852.—SEDGWICK, "On the Lower Palæozoic Rocks at the base of the Carboniferous Chain between Ravenstonedale and Ribblesdale," Quart. Journ. Geol. Soc., vol. viii. p. 35. *Orthoceras subundulatum* and *O. primævum* are recorded from Heaton.

1852.—STRICKLAND, "On a protruded Mass of Upper Ludlow Rock at Hagley Park, in Herefordshire," Quart. Journ. Geol. Soc., vol. viii. p. 381, records *Orthoceras bullatum*, *O. ibex*, *O. perelegans*, and *O. gregarium*, from the above rock.

1852.—M'COY, 'A systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge,' second fasciculus. In this work the fossils, old or new, are described, and the new ones figured. A number of Bellerophons are described as Cephalopods, being placed in a parallel family with Nautili and Ammonites. The true Cephalopoda described are—*Cyrtoceras multicameratum* (Hall), *Orthoceras angulatum* (Wahl.), *O. Brightii* (Sow.), *O. bullatum* (Sow.), *O. centrale* (His.), *O. dimidiatum* (Sow.), *O. filosum* (Sow.), *O. imbricatum* (Wahl.), *O. laqueatum* (Hall), *O. ludense* (Sow.), *O. mocktreense* (Sow.), *O. politum* (M'Coy), *O. primævum* (Forbes), *O. semipartitum* (Sow.), *O. subundulatum* (Portl.), *O. tenuicinctum* (Portl.), *O. tenuistriatum* (Münst.), *O. vagans* (Salt.), *O. ventricosum* (Sharpe), *O. annulatum* (Sow.), *O. arcuoliratum* (Hall), *O. bilineatum* (Hall), *O. ibex* (Sow.), *O. subannulatum* (Münst.), *O. tracheale* (Sow.), as well as *O. baculiforme* and *O. tenuiannulatum*, which are figured as new (Pl. I., L). Also *Poterioceras pyriforme* (Sow.) and *P. ellipticum* (M'Coy); *Phragmoceras intermedium* (M'Coy) and *P. ventricosum* (Sow.); *Lituites articulatus* (Sow.) and *L. cornu-arietis* (Sow.); *Trocholites planorbiformis* (Conrad) and *T. anguiformis*, figured as new; and *Hortolus giganteus* (Sow.) and *H. ibex* (Sow.). To this fasciculus is added an Appendix A, called "Descriptions of a few Species from Wales and Westmoreland referred to in the foregoing work," by J. W. SALTER. In this are described, some being figured on the above-mentioned plate, *Orthoceras vagans* (Salter), *O. dimidiatum* (Sow.), *O. torquatum* (Münster), *O. primævum* (Forbes), *O. ventricosum* (Sharpe), *O. ibex* (Sow.), *Lituites planorbiformis* (Conrad), *L. cornu-arietis* (Sow.), and the two new species, *Orthoceras baculiforme* and *Lituites anguiformis.* We thus have double and differing descriptions of the same specimens in many cases.

1853.—STRICKLAND, "On the Distribution and organic Contents of the Ludlow Bone-bed, in the districts of Woolhope and May Hill," Quart. Journ. Geol. Soc., vol. ix. p. 8, records *Orthoceras semipartitum* from this bed.

1853.—SEDGWICK, "On a proposed Separation of the so-called Caradoc Sandstone into two distinct groups, viz. (1) May Hill Sandstone, and (2) Caradoc Sandstone," Quart. Journ. Geol. Soc., vol. ix. p. 215, records *O. annulatum* from May Hill Sandstone.

1853.—SALTER, "On a few Genera of Irish Silurian Fossils," Brit. Assoc. Rep. for 1852, p. 59. *Lituites hibernicus* from Bala Limestone, Kildare, is described as new, but is referred with doubt to the genus *Trocholites.*

1853.—SEDGWICK, "Geology of the Lake District of Cumberland, Westmoreland, and Lancashire, in letters addressed to W. Wordsworth, Esq.' On page 97 the Cephalopods found in the Silurian rocks of this district are catalogued as *Orthoceras filosum, O. laqueatum, O. vagans, O. subundulatum, O. tenuicinctum, Cycloceras annulatum, C. ibex, C. subannulatum,* and *Lituites cornu-arietis*, as from the "Cambrian," and *Orthoceras angulatum, O. baculiforme, O. bullatum, O. dimidiatum, O. imbricatum, O. laqueatum, O. subundulatum, O. tenuicinctum, Cycloceras ibex, C. subannulatum, C. tenuiannulatum, C. tracheale*, and *Hortolus ibex*, as from the "Silurian."

1854.—MORRIS, 'A Catalogue of British Fossils,' 2nd edition. The Silurian Cephalopoda enumerated comprise—3 *Actinoceras,* being species here first referred to this genus, which was founded on Carboniferous forms; 3 *Cyrtoceras*; 11 *Lituites,* the genera *Hortolus* and *Trocholites* not being adopted; 55 *Orthoceras*, and 10 *Phragmoceras.*

1858.—SALTER, "On a new genus of Cephalopoda, *Tretoceras* (*Orthoceras bisiphonatum*, Sowerby), and on the occurrence of the genus *Ascoceras* (Barrande) in Britain," Quart. Journ. Geol. Soc., vol. xiv. p. 177. New details are given about the first-named species, and it is compared to an inturned *Gonioceras*, and the second species is named *A. Barrandei*; both are illustrated by figures.

1858.—BAILY, 'Data and Descriptions to accompany Quarter Sheet 35 N.E. of the Maps of the Geological Survey of Ireland,' records *Orthoceras subgregarium* and *O. tenuicinctum* from Caradoc Limestone, Chair of Kildare.

1859.—SALTER, in a paper by Murchison, "On the Succession of the older Rocks in the northernmost counties of Scotland, with some Observations on the Orkney and Shetland Islands," Quart. Journ. Geol. Soc., vol. xv. p. 374. The Cephalopoda from the Durness Limestone are described as *Orthoceras arcuoliratum* (Hall), *O. vertebrale* (Hall), *O. undulosostriatum* (Hall), and a new species named *O. mendax.* A new genus of remarkable character, referred to the same class, is described under the name of *Piloceras,* of which there are recognised two species, one only being named as *P. invaginatum.* All these are figured, as well as a fossil referred to the genus *Oncoceras* (Hall).

1859.—'Memoirs of the Geological Survey.' "The South Staffordshire Coalfield," by J. B. Jukes. The fossils are named by SALTER, who records *Orthoceras annulatum* from the Barr Limestone; *Phragmoceras pyriforme* from the Wenlock Shale; *Orthoceras annulatum*, with var. *fimbriatum, Phragmoceras pyriforme, Lituites cornu-arietis* and *tortuosus* from the Dudley Limestone; and *Orthoceras angulatum, O. bilineatum, O. annulatum* and *O. perelegans, Phragmoceras compressum, Lituites giganteus* and *L. articulatus*, from the Lower Ludlow rocks.

1859.—SALTER, 'Geological Survey of Great Britain,' Explanation of Horizontal Section, Sheet 45, records *Phragmoceras ventricosum*, *P. pyriforme*, *Lituites giganteus*, *Orthoceras subundulatum*, *O. filosum*, *O. ludense*, from the Lower Ludlow, and *Orthoceras angulatum*, *O. ibex*, and *O. bullatum*, from the Upper Ludlow, Coalbrookdale.

1860.—JUKES and DU NOYER, "On the Geological Structure of Caherconree Mountain," Journ. Geol. Soc. of Dublin, vol. viii. p. 106, record *Orthoceras subundulatum*, from Upper Silurian.

1860.—BAILY, "Notice of Lower Silurian Fossils in County Tipperary," Journ. Geol. Soc. of Dublin, vol. viii. p. 110, records *Orthoceras lineatum*, *O. elongatocinctum*, *O. tenuicinctum*, *O. ibex*, and *O. pseudoregulare*, from the Lower Silurian rocks of that county.

1860.—KELLY, "On the Grauwacké Rocks of Ireland as compared with those of England," Journ. Geol. Soc. of Dublin, vol. viii. p. 251. A large number of localities is given for Irish Silurian Cephalopoda, but not, as it appears, from original observation.

1860.—BAILY, in the 'Explanation to accompany Sheet 135,' and in the 'Explanation to accompany Sheet 145,' of the Geological Survey of Ireland, records the same species as above from co. Tipperary, and in the latter memoir gives a figure of *Orthoceras elongatocinctum.*

1861.—SALTER, in a paper by W. S. Symonds and A. Lambert, "On the Sections of the Malvern and Ledbury Tunnel, and the intervening Line of Railroad," Quart. Journ. Geol. Soc., vol. xvii. p. 152, mentions the occurrence of a new genus from the Lower Ludlow Shales. He describes it as unsymmetrical, like *Helicoceras*, but belonging to the Nautiloidea. He does not give it any name, nor state whether it is the *Trochoceras* of Barrande.

1861.—'Memoirs of the Geological Survey of Great Britain,' Sheet 32, Scotland: "The Geology of the Neighbourhood of Edinburgh," by H. Howell and A. Geikie; appendix and list of fossils, by A. W. SALTER. The last-named writer describes a new species of *Orthoceras*, *O. Maclareni*, and records the presence of *O. subundulatum* in the Upper Silurian of the Pentlands.

1861.—BAILY, 'Explanations to accompany Sheets 102 and 112 of the Maps of the Geological Survey of Ireland,' records *Orthoceras tenuicinctum*, and a new species to which the name of *O. remotum* is given, without characters being assigned, from the Lower Silurian of Portraine.

1862.—BAILY, 'Explanations to accompany Sheet 126,' &c., records *Orthoceras filosum* and *O. angulatum*, from the Lower Silurian Fairymount.

1862.—BAILY, 'Explanatory Memoir to Sheet 133,' &c., records *Orthoceras angulatum*, *O. Brongniarti*, *O. elongatocinctum*, *O. lineatum*, *O. subundulatum*, and *O. tenuicinctum*, from the Lower Silurian.

1863.—SALTER, 'Explanation of Sheets 160, 161, 171, and part of 172, of the Geological Survey of Ireland,' records *Orthoceras annulatum* from Croaghmashin; and BAILY, *O. angulatum* and *O. subundulatum* from Derrymore Glen.

1865.—HARKNESS, "On the Lower Silurian Rocks of the South-east of Cumberland and the North-east of Westmoreland," Quart. Journ. Geol. Soc., vol. xxi. p. 235, records *Orthoceras Brongniarti* from the Dufton Shales, and *O. politum* and *O. vagans* from the Keisley Limestone.

1865.—HASWELL, "On the Silurian Formation of the Pentland Hills." Printed from a paper read before the Geological Society of Edinburgh. In this book the author describes the Cephalopods found in the above-named district under the names of *Orthoceras politum*, *O. Maclareni*, *O. tenuiannulatum*, and *O. subundulatum*, and illustrates them by figures.

1865.—D. C. DAVIES, "List of Fossils described from the Bala Limestone, and its associated Beds in North Wales." Abstract of Proceedings of the Liverpool Geological Society, Session VI. The fossils enumerated are *Orthoceras politum*, *O. subundulatum*, *O. vagans*, *O. ventricosum*, *O. annulatum*, *Phragmoceras arcuatum*, *Lituites cornu-arietis*, and *L. anguiformis.*

1865.—BAILY, 'Explanatory Memoir to Sheets 167, 168, 178, and 179, of the Geological Survey of Ireland,' records *Cyrtoceras inæquiseptum*, *Orthoceras Brongniarti*, and *O. tenuicinctum*, from the Lower Silurian of co. Waterford.

1866.—SALTER, 'Appendix to Vol. III. of the Memoirs of the Geological Survey of Great Britain:' "The Geology of North Wales," by A. C. Ramsay. He records the various Cephalopoda found in the rocks in the district, which are too numerous to enumerate here; none of them are new introductions except those to be mentioned below. The new species described and figured are *Orthoceras sericeum* and *Cyrtoceras præcox*, from the Tremadoc Slates; *Orthoceras encrinale* and *O. Avelinii*, from the Llandeilo Flags; *Cyrtoceras sonax* and *C. atramentarium*, and *Orthoceras audax*, from Bala Limestone; from which rock also illustrations are given of *Orthoceras vagans* and *Lituites planorbiformis.*

1866.—R. HARKNESS and H. NICHOLSON, "Additional Observations on the Geology of the Lake Country," Quart. Journ. Geol. Soc., vol. xxii. p. 480, record *Orthoceras filosum*, *O. tenuicinctum*, and *O. subannulatum*, from Coniston Flags.

1866.—WYATT EDGELL, "On a Species of Lichas and other new Forms from the Llandeilo Flags," Geological Magazine, vol. iii. p. 160, records from these beds *Orthoceras subundulatum* and *Endoceras eoum*, the latter being new, but the name is unaccompanied by any figure or description.

1866.—MORTON, "On the Geology of the Country bordering on the Mersey and on the Dee," Liverpool Naturalists' Journal, No. 1, records *Orthoceras primævum*, from the Wenlock Shales.

1867.—HUGHES, "On the Break between the Upper and Lower Silurian Rocks

of the Lake district, as seen between Kirby Lonsdale and Malham, near Settle," Geol. Mag., vol. iv. p. 346, records *Lituites giganteus*, *Orthoceras primævum*, *O. subundulatum*, *O. ventricosum* (?), *O. ludense*, *O. bullatum*, and *O. angulatum*, from the Coniston Flags.

1867.—R. Dixon, "Upper Silurian Fossils," Transactions of the Woolhope Naturalists' Field Club, Fossil Sketches, No. 1, gives figures of *Orthoceras bullatum*, *O. ibex*, *O. ludense*, *O. annulatum*, and *Phragmoceras pyriforme*, from the neighbourhood of Hereford.

1868.—Nicholson, 'An Essay on the Geology of Cumberland and Westmoreland.' In this book is recorded *Orthoceras Brongniarti*, from the Dufton Shales, and from the Coniston Limestone is given M'Coy's previously published list, with the addition of *O. politum* and *O. vagans*; and from the Coniston Flags, *O. primævum*.

1868.—Bigsby, 'Thesaurus Siluricus; the Fauna and Flora of the Silurian Period.' The Cephalopoda recorded in this catalogue as occurring in Great Britain are *Actinoceras* 4, *Ascoceras* 1, *Cycloceras* 5, *Cyrtoceras* 9, *Endoceras* 1, *Gomphoceras* 2, *Lituites* 11, *Oncoceras* 4, *Orthoceras* 73, *Phragmoceras* 9, *Piloceras* 1, *Tretoceras* 1, *Trochoceras* 2, *Trocholites* 2; but these numbers are subject to discount, since when a species has been referred to two genera it is found enumerated under both. There are also several unpublished names.

1869.—Salter, 'Explanation of Sheet 24 of the Geological Survey of Scotland,' records *Orthoceras ibex* and *Lituites cornu-arietis*, from the Wrae Limestone.

1869.—Morton, "The Geology and Mineral Veins of the country round Shelve, Shropshire, with a Notice of the Breidden Hills," Proc. Liverpool Geol. Soc., records *Orthoceras Avelinii* and *O. encrinale* from the Lower Llandeilo, and *O. conicum* and *Lituites cornu-arietis* from Upper Llandovery of this district.

1869.—Nicholson, "Notes on the Green Slates and Porphyries of the neighbourhood of Ingleton," Geol. Mag., vol. vi. p. 213, records *Orthoceras Brongniarti* (?), from the former.

1869.—Baily, 'Figures of Characteristic British Fossils,' with descriptive remarks, Pt. 1. He gives original figures and notes of *Orthoceras elongatocinctum* and *O. vagans*, from Bala Beds.

1870.—Baily, 'Explanatory Memoir of Sheet 95 of the Geological Survey of Ireland,' records *Orthoceras subgregarium* from Upper Llandovery rocks, Cong.

1870.—D. J. Brown and J. Henderson, "On the Silurian Rocks of the Pentland Hills," Trans. Edinb. Geol. Soc., vol. i. p. 23, record *Orthoceras Maclareni*, *O. subundulatum*, *O. gregarium*, *O. excentricum*, *O. angulatum*, *Phragmoceras compressum* and *Lituites* sp., from beds as numbered by the Geological Survey.

1871.—Geikie, A., "On the Order of the Succession among the Silurian Rocks of Scotland," Trans. Geol. Soc. Glasgow, vol. iii. p. 74, records various Cephalopoda, but apparently the data are all derived from previous lists.

1871.—C. Lapworth and J. Wilson, "On the Silurian Rocks of the Counties of Roxburgh and Selkirk," Geol. Mag., vol. iii. p. 456, record *Orthoceras tenuicinctum*, *O. ibex*, and *O. tracheale*, from Riccarton.

1872.—Etheridge, 'Memoirs of the Geological Survey Sheet, 98 N.E.:' "Geology of the country round Kendal, Sedbergh, Bowness, and Tebay," records *Lituites giganteus*, *Orthoceras ibex*, *O. ludense*, *O. primævum* and *O. subundulatum*, from the Coniston Grits.

1872.—Etheridge, 'Memoirs of the Geological Survey Sheet, 98 S.E.:' "Geology of the neighbourhood of Kirby Lonsdale and Kendal," records *Orthoceras primævum*, from the Coniston Flags; *O. subundulatum*, *O. angulatum*, *O. ludense*, *O. primævum*, *O. virgatum*, and *Trochoceras* sp., from Coniston Grits; *O. angulatum*, *O. bullatum* and *O. tracheale*, from Ludlow rocks.

1872.—Nicholson, "On the Occurrence of the genus *Endoceras* in Britain," Geol. Mag., vol. ix. p. 102, describes a surface fragment from Coniston Mudstones as *Endoceras proteiforme* (Hall).

1873.—Salter, 'A Catalogue of the Collection of Cambrian and Silurian Fossils contained in the Geological Museum of the University of Cambridge,' records *Orthoceras sericeum* from Tremadoc Slates, *Cyrtoceras multicameratum* (Hall), *Orthoceras centrale* (?) and *O. fluctuatum*, the last a new species, from the Lower Bala; *Orthoceras vagans*, *O. politum*, *O. bilineatum*, *O. annulatum*, *O. ibex*, *O. arcuoliratum*, *Ormoceras* sp., *Lituites cornu-arietis*, *L. anguiformis*, *L. planorbiformis*, from Middle Bala; *Orthoceras tenuistriatum*, Upper Bala; *Phragmoceras ventricosum* and *Orthoceras annulatum*, from May Hill Sandstone; *Orthoceras subundulatum*, *O. primævum*, *O. ventricosum*, *O. angulatum*, *O. subannulatum*, *O. tenuicinctum*, *O. laqueatum*, *O. dimidiatum*, *O. tracheale*, *O. annulatum*, and *Trochoceras* sp., from Wenlock Shales;—*Orthoceras angulatum*, *O. dimidiatum*, *O. annulatum*, and var. *fimbriatum*, *O. Brightii*, *O. mocktreense*, *O. ludense*, *O. canaliculatum*, *O. subundulatum*, *O. tenuicinctum*, *O. perelegans*, *O. ibex*, *O. dulce* (Barr.), *O. laqueatum*, *O. subannulare*, *O. primævum*, *O. ventricosum*, *O. distans*; *Phragmoceras ventricosum*, *P. pyriforme*, and *P. æquale*, the last-named being a new species; *Cyrtoceras Biddulphii*, *C. compressum*, *C. corniculum* (Barr.), *Trochoceras giganteum*, and *T. spurium*, the last a new species, all from the Wenlock Limestone;—*Orthoceras filosum*, *O. dimidiatum*, *O. ibex*, *O. tenuiannulatum*, *O. angulatum*, *O. subundulatum*, *O. perelegans*; *Phragmoceras ventricosum*, *P. intermedium*, *P. pyriforme*, *P. liratum*, a new species; *Trochoceras giganteum* and *Lituites articulatus*, from the Lower Ludlow;—*Orthoceras ibex*, *O. bullatum*, *O. angulatum*, *O. subundulatum?* *O. Maclareni*, *O. tenuicinctum*, *O. torquatum*, *O. tenuiannulatum*, *O. tracheale*, *O. imbricatum*, *O. dimidiatum*, *O. baculiforme*, *O. perelegans*, from the Upper Ludlow; and *Orthoceras tracheale*, *O. bullatum*, and *Tretoceras semipartitum*, from the Passage Beds.

1873.—Hicks, "On the Tremadoc Rocks in the Neighbourhood of St. David's,

South Wales, and their Fossil Contents," Quart. Journ. Geol. Soc., vol. xxix. p. 51, figures an *Orthoceras* from Tremadoc Slates, too imperfect to name, but apparently different from *O. sericeum.*

1874.—Barrande, 'Système Silurien du Centre de la Bohême,' vol. ii. part 3, describes and figures *Orthoceras Thompsoni*, from the Silurian (part unknown) of Scotland.

1874.—J. F. Brown, "The South Wales Coalfield," North of England Institute, vol. xxiii. p. 197, records *Orthoceras* sp., and *Lituites articulatus*, from the Silurian in the neighbourhood of Cardiff.

1875.—Hicks, "On the Succession of the Ancient Rocks in the vicinity of St. David's, Pembrokeshire, with special reference to those of the Arenig and Llandeilo groups, and their Fossil Contents," Quart. Journ. Geol. Soc., vol. xxxi. p. 180 (?), describes and figures *Orthoceras caereesiense* as a new species from the Upper Arenig rocks.

1876.—Hicks, in a paper by J. E. Marr, "On Fossiliferous Cambrian Shales near Carnarvon," Quart. Journ. Geol. Soc., vol. xxxii. p. 134, records *O. caereesiense* from this locality.

1877.—Harkness and Nicholson, "On the Strata and their Fossil Contents between the Borrowdale Series of the North of England and the Coniston Flags," Quart. Journ. Geol. Soc., vol. xxxiii. p. 461, record *Orthoceras vagans* from Keisley; *Endoceras proteiforme* and *Orthoceras angulatum*, from the Mudstones.

1878.—Marr, "On some well-defined Life-zones in the lower part of the Silurian (Sedgwick) of the Lake District," Quart. Journ. Geol. Soc., vol. xxxvi. p. 871, records *Orthoceras vagans* and a sp. like *O. Troostii*, *Cyrtoceras sonax*, and *Lituites cornu-arietis*, from the Coniston Limestone, also *Orthoceras* sp. allied to *O. dulce*, *O. laqueatum*, *O. tenuicinctum*, *O. bilineatum*, *O. subundulatum*, and *O. subannulatum*, from the Middle Caldwell Beds; *O. tenuicinctum*, from the Upper Caldwell Beds.

1879.—Sollas, "On the Silurian District of Rhymney and Pen-y-lan, Cardiff," Quart. Journ. Geol. Soc., vol. xxxv. p. 475, records *O. angulatum,* from the Llandovery, Wenlock, and Ludlow Beds of Cardiff.

DESCRIPTION OF THE SPECIES.

Suborder NAUTILOIDEA.

Group I. Conici.

Genus Orthoceras.

Group I. Brevicones.

1. Orthoceras Barrandei, Salter, Pl. XVIII. figs. 10, 11, 12; Pl. XIX. figs. 4, 4a.

1851. Orthoceras Barrandei, Salter, 'Quart. Journ. Geol. Soc.' vol. vii. p. 137.
Syn. Gomphoceras liratum, Salter, 'Camb. and Silur. Fossils,' p. 174.
Query, Cyrtoceras æmulus, Barrande, 'Syst. Sil. de Bohême,' pl. 240, figs. 7–10.

Type.—This has not been found. From the figure and description, the specimen appears to be flattened, and then has an apical angle of 40°. It is represented as commencing with a point, and one side is rather curved while the other is straight. The body-chamber has a length equal to its own basal diameter; the aperture is simple. The ornaments are oblique lines of growth, about three per line. The septa are distant one-sixth the diameter, and are parallel to the ornaments. The greatest diameter is ten lines, and the length twenty lines. From the Llandovery Beds; Mullock.

General Description.—The type specimen not being available, and yet the species being a well-marked one, I was for a long time surprised that no representative was forthcoming in any collection, till a comparison of the shell called *Gomphoceras liratum*, in the Woodwardian Museum (Pl. XVIII. fig. 10), with Salter's description, showed that they must be identical. The section is doubtful, unless the specimen (fig. 12), subsequently referred to, really belongs here, in which case it was elliptic, the axes being in the ratio of 12 to 11. The rate of increase is about 4 in 7 on the whole shell; but it is much less in the body-chamber than in the septal portion, which gives the shell a vase-like appearance, and has led to its being placed in the genus *Gomphoceras.* The body-chamber has a length equal to its diameter (fig. 10), and the aperture is simple and undulating (fig. 11). The surface is ornamented with fine lines nearly parallel to the septa, but slightly curving away from the aperture. In the septal portion these are close together, four per line; but on the body-chamber they are only half as numerous, and become much stronger near the aperture. The septa are direct; and though in fig. 11 they appear to undulate, this may be due to contortion. They are very close, not more than a line apart. In one example, not

figured, the siphuncle appears to be nearly marginal, and its elements globular. The specimen figured in Pl. XVIII. fig. 12, shows similar ornaments and rate of increase, but this may be due to flattening, and the specimen may possibly be a *Gomphoceras*. If it really belongs to the present species, the excentric siphuncle, $\frac{1}{5}$ from the circumference on the long diameter, is confirmed, and the septa shown to be almost flat, and to have vascular markings connected with two small pits on the surface. The tendency shown by the shell to be contorted in youth, as seen in Pl. XVIII. fig. 11, might lead some examples, such as that figured on Pl. XIX. figs. 4, 4A, to be taken for *Cyrtoceras*; but the resemblance to the type is too great, in shape, ornaments, septa and siphuncle, to admit of its separation, allowance being always made for compression, which produces an apparent curvature. The largest example is $1\frac{3}{4}$ inches in length and extreme breadth.

Relations.—Nothing British is in any way comparable with this, but Barrande's species, *Cyrtoceras æmulus*, is very like the young form.

Distribution.—The type is from Upper Silurian Beds of Scotland, called Llandovery Beds. The specimens examined are from the Wenlock Limestone and Shale of Dudley (3) and of Ledbury (1), and from the Lower Ludlow of Aymestry (1).

2. Orthoceras xit, Blake, Pl. XVIII. fig. 9.

Type.—The section is probably compressed, but is now elliptic with the axes in the ratio of 3 to 2. There is considerable curvature on one side, of minimum radius 1 inch, but the other side is straight, or nearly so. The body-chamber, which has a length one and a half times its longer basal diameter, and ends with a simple aperture, is cylindrical; the septal portion of the shell rapidly tapers off to a much smaller diameter, the end being probably lost. The surface is smooth, except for lines of growth. The septa are slightly oblique, sloping backwards towards the more convex side, and are distant about $\frac{1}{4}$ the mean diameter. No siphuncle is seen. The greatest diameter is $\frac{3}{4}$ in., and the length 13 lines. From the Wenlock Shale of Dudley. In the British Museum.

Relations.—This small and solitary ill-preserved specimen is of importance, as indicating a second brevicone *Orthoceras*, or perhaps *Cyrtoceras*, in British rocks. It is not unlike Barrande's *O. semisecans*, except for the direction of the septa, nor to some of his figures of small *Cyrtocerata*, but until further data are forthcoming it is safer to quote it under a distinct name.

3. Orthoceras hungaricum, Blake, Pl. XVIII. fig. 8.

Type.—The section is elliptic, the diameter being in the ratio of 6 to 5; the apical angle is about 38°, the shell commencing nearly at the apex. The body-chamber is a little longer than its breadth, and is nearly $\frac{2}{3}$ of the whole shell. The

outline of the aperture, if really preserved, is slightly undulating. The specimen is a cast, and hence no ornaments appear. The septa slope in a slightly different direction to that of the aperture, and are about $\frac{1}{7}$ the diameter apart. The length is $1\frac{2}{3}$ inches, and the greatest breadth 10 lines. From the Bala Series of Haverfordwest. In the Museum of Practical Geology.

Distribution, &c.—No other specimen has been seen, but the remarkably large angle of increase can scarcely admit of any doubt of the distinctness of this species. In shape it is not unlike *O. Barrandei*, but has not its ornaments. It is the earliest of our Brevicones.

Group II. Longicones.

Section Annulati.

Orthoceras mendax, Salter, Pl. III. fig. 1.

1859. Orthoceras mendax, Salter in Murchison's 'Northern Highlands, &c.;' Quart. Journ. Geol. Soc., vol. xv. pl. xiii. fig. 24, p. 374.
1872. Orthoceras sp., Salter in Murchison's 'Siluria,' Foss. gr. 27, fig. 6, p. 165.

Type.—Salter's figure is made up of three pieces not belonging to the same individual, though of the same species. He states the section to be circular. The rate of increase is 1 in 8. No portion of the body-chamber is seen. The ornaments are transverse, rather acute, ribs, almost direct, and distant $\frac{1}{5}$ the diameter. No finer ornaments are preserved. Salter states that the young is nearly smooth, but this may be from wear. The septa correspond to the elevation of the ribs, and are therefore distant $\frac{1}{5}$ the diameter, and nearly direct; their convexity is slight. The siphuncle is said to be eccentric, but this appears to me due to compression, as only half of the upper part is preserved; moreover it is drawn (fig. 24*b*) as central. There are enlargements of the septa in the neighbourhood of the siphuncle, which I take to be the remains of the obstructing deposits; and thus the exterior sheath of the siphuncle, which usually represents it, is gone, and we have left the usually corneous inner tube, passing through the septa without any signs of constriction. This inner tube is thus perfectly smooth, except for a longitudinal fold, as if it were a membrane in too small a case, and has a diameter $\frac{2}{9}$ that of the shell; the whole siphuncle being about $\frac{1}{3}$ the diameter. The largest single fragment is 2 in. long by 10 lines. From the Durness Limestone. In the Museum of Practical Geology.

General Description.—I am not certain I have seen the specimen supposed to be young, without ribs; but two examples, otherwise valuable, have so suffered from 'beekisation,' as many of the fossils from this limestone have, that every sign of ribs is lost. Including these, and others with extra sharp ribs, as examples, the section was

certainly circular, though generally compressed. The rate of increase is usually 1 in 10. No body-chamber is seen. The ornaments slightly undulate, and are distant $\frac{1}{5}$ the diameter. They do not seem to be less, but perhaps even more acute when young; but the beekised specimens are small ones. The septa have but slight convexity and are from $\frac{1}{4}$ to $\frac{1}{5}$ the diameter apart, appearing always to correspond to ribs. The siphuncle is seen to be central, at least when the shell is small, and then has a diameter of $\frac{1}{3}$ to $\frac{2}{5}$ of the whole as seen on the end. This consists of the renal obstructions which become amalgamated with the septa, and are almost lost, and of a comparatively large-sized inner tube, untouched by the septa and slightly folded longitudinally; these features are seen in all specimens showing the interior, and prove that we have here a very remarkable type with a siphuncle of two distinctly preserved layers, the outer one being separated by obstructing deposits from the inner one. The type is the largest of the specimens, and there are some from $\frac{1}{4}$ inch downwards.

Relations.—Salter compares this with *O. multicameratum* of Hall, but I regard the present as a ribbed species; and in any case the siphuncular arrangement, if rightly interpreted, separates this from Hall's species, and indeed from all comparable ones.

Distribution.—From the "Lower Llandeilo" Limestone of Durness (8). It is the commonest Cephalopod of these rocks, and I have seen several others besides those critically examined.

ORTHOCERAS BACULOIDES, Blake, Pl. III. fig. 2.

Type.—The section is nearly circular, and the rate of increase is 1 in 18. Only a fragment is seen, showing the surface. This has semi-annulations sloping back 20°, and dying away on the lower side; these are $\frac{1}{2}$ the diameter apart, and there are feeble intermediate lines. The siphuncle is central and large. The length is $2\frac{1}{2}$ inches, and the greatest diameter 5 lines. From the "Llandeilo" Limestone of Durness. In the Museum of Practical Geology.

General Description and Relations.—Two other examples, slightly compressed into an oval, show an equally slow tapering, and one shows a central siphuncle; these features seem to separate the specimens from *O. durinum*, whose exterior surface is not known, while in *O. arcuoliratum* the ornaments are stronger. Nevertheless, this is an imperfectly known form.

Distribution.— Only found in the Durness Limestone (3).

Orthoceras durinum, Blake, Pl. III. figs. 3, 3*a*.

Syn. 1859. Orthoceras undulosostriatum, Salter in Murchison's 'Northern Highlands, &c.,' Quart. Journ. Geol. Soc., vol. xv. pl. xiii. figs. 25, 26, p. 375. (Not of Hall.)
Query, Orthoceras arcuoliratum, Salter, loc. cit., p. 375. (Not of Hall.)

Type.—This is the specimen figured by Salter (fig. 26) as above. Its section is now oval in the ratio of 5 to 6, but may naturally be circular. The rate of increase is 1 in 45. No body-chamber is seen. The surface is entirely worn away and beekised; the apparent ribs are due entirely to unequal weathering, and such ornaments, to judge from the specimen, may or may not have been present. The septa are moderately convex, and are oblique 22° on the sides, but direct dorsally and ventrally: in one of these positions they are less worn away over a limited area, and this has produced an appearance of a sinus which does not really exist. The siphuncle is not actually seen, but it is probable that this preservation may be due to its presence, in which case it is marginal, on the side to which the septa slope back. There are depressed lines on the casts of the chambers parallel to the septa; these may be due either to internal projections, or may indicate a line of absence of the encrusting deposit on the septa. Length $1\frac{1}{4}$, in diameter $\frac{1}{2}$ inch. From the Durness Limestone. In the Museum of Practical Geology.

General Description.—The section has not been observed circular, and the tapering is very slow. If, as I think, the specimen referred to by Salter as *O. arcuoliratum*, belongs here, and it agrees in other characters, then there were certainly rather acute ribs of 20° obliquity, distant $\frac{2}{9}$ the diameter, and this is probable in any case. The septa are oblique 20°–24°, and correspond to the interval between the ribs; they are distant $\frac{2}{9}$ to $\frac{2}{11}$ the diameter. In none has the siphuncle been seen, but in one, besides the type, are some peculiar features, which indicate it as marginal on the side to which the septa slope back, as from the great obliquity of the latter we might expect; in this case there is no unequal wearing, and hence no appearance of a sinus, but there are two impressed lines which lie between and are parallel to each pair of septa over a limited area, which I interpret as the limit, on each side of the neck of the septum, of the usual encrusting deposit. The peculiar appearance indicated by Salter in his fig. 25 is due merely to some septa having been broken through and their remaining edges being worn away. The type is the largest seen.

Relations.—This species has undoubtedly some considerable resemblance to Hall's *O. undulosostriatum*, but in that the siphuncle is nearly central, whereas, if my interpretation of appearances is the right one, *O. durinum* has it lateral: also, the arch in the septa and in the supposed ribs being only due to weathering, one great point of resemblance disappears. No finer ornaments are here for

comparison, and the likeness is reduced to the slowness of the tapering and the obliquity of the ribs. From *O. mendax* and *O. arcuoliratum*, the great obliquity of the septa and marginal position of the siphuncle, two characters which usually go together, separate it.

Distribution.—In the "Lower Llandeilo" Limestone of Durness (6); hence the name.

ORTHOCERAS ARCUOLIRATUM (?), Hall, Pl. III. figs. 14, 14*a*.

1848.	ORTHOCERAS	ARCUOLIRATUM,	Hall, 'Palæontology of New York,' t. 42, fig. 7, p. 198.
1852.	"	"	M'Coy, 'Palæozoic Fossils,' p. 319.
1859.	"	"	Salter, 'Quart. Journ. Geol. Soc.,' vol. xv. p. 375.
1873.	"	"	Salter, 'Cambrian and Silurian Fossils,' p. 71.

Type.—The section is circular, and the rate of tapering in the figured specimens is 1 in 10. The ornaments are "strong and extremely arching or undulating annulations, about equal to the spaces between, and obscure fine longitudinal striæ." The septa are not described, but the figure shows them to have a considerable convexity and an obliquity of about 10°, but their distance is unknown. The siphuncle is central and moderate in size. Diameter $\frac{1}{2}$ inch. From the Trenton Limestone.

General Description.—The most probably identified British specimen known is that referred by M'Coy to the above, and which agrees with it so far as its characters are preserved. The section is nearly circular, and the rate of increase is 1 in $6\frac{1}{2}$. The ribs are obtuse, slightly imbricating forwards, and show something of the strangulated appearance noticeable in Hall's figure; they are 8° oblique, and are distant $\frac{2}{7}$ the diameter. M'Coy noticed longitudinal striæ on the specimen, which I could not find. Siphuncle central.

Relations.—It will be seen that this specimen increases at a more rapid rate than the type, and the septa are unknown; it may, therefore, belong to a different species. It may be the same as Salter's, whose siphuncle is not seen, but *O. arcuoliratum* differs from *O. durinum* by having that organ central.

Distribution.—In the Middle Bala, Wrae, Broughton (1); in the Woodwardian Museum, and possibly in the Durness Limestone (1).

ORTHOCERAS PERANNULATUM, Portlock, Pl. III. fig. 4.

1843.	ORTHOCERAS	PERANNULATUM,	Portlock, 'Geol. Report,' t. 25, figs. 5, 6, p. 367.
1866.	"	ENCRINALE,	Salter, 'Mem. Geol. Surv.,' vol. iii. pl. ii. *b*, fig. 20, p. 356.
1872.	"	"	Salter in Murchison's 'Siluria,' Foss. gr. 9, fig. 10, p. 48.

Type.—One large and one small specimen were described by Portlock. Neither gives the shapes of section or true tapering, as they consist of surface-markings only. The ribs are of a rounded separate character, as preserved, and are more clearly

marked in the small specimen. They are about 3° oblique to the general diameter, but run rather irregularly, and their closeness varies: at the small end of the small specimen they are very close, and end by being $\frac{2}{11}$ the preserved diameter apart; in the large specimen they are closer at the large end, where they are at $\frac{1}{13}$ the flattened diameter apart. The surface is covered with an irregular granulation, something like shagreen. No septal or siphuncular characters are certainly seen; but towards the larger end, at a diameter of $2\frac{1}{2}$ inches, there are depressed bands, as if a rectangular piece of tape had been impressed on the surface, leaving lines which might be taken for sutures. The large specimen attains a diameter of $3\frac{1}{2}$ inches. From the Bala Series of Desertcreat. In the Museum of Practical Geology.

General Description.—There are no specimens known which give better characters than the type, but the number and strength of the ribs remain the chief features of the species. The specimens referred by Salter to a new species under the name *O. encrinale* show no more than this, though the ribs have a maximum of strength. At the best the whole series form a doubtful species, as it would run close to others if the surface were well enough preserved to show any minor ornaments. A specimen from Bala Limestone, in the Museum of Practical Geology, labelled *O. multiannulatum*, which appears to belong here, has an oval section, and the siphuncle seems to be midway between the centre and the circumference on the long diameter.

Relations.—From *O. arcuoliratum* this differs by the number of the ribs, and from *O. velatum* by their less rounded character and greater irregularity.

Distribution.—In the Bala Beds of Desertcreat (5), of Bala (1), of Llandeilo (1), and Wrexham (1); also in the Lower Llandeilo of Shropshire (2) [*O. encrinale*].

Orthoceras gracile, Portlock, Pl. III. figs. 5, 5*a*; 9, 9*a*, 9*b*, 9*c*.

1843. Orthoceras gracile, Portlock, 'Geol. Rep.,' pl. 25, fig. 2, p. 366.
Syn. 1843. Orthoceras tubicinella, Portlock, 'Geol. Rep.,' pl. 25, fig. 34. (Not of Sowerby.)
1843. „ calamiteum, Portlock, 'Geol. Rep.,' pl. 25, fig. 1. (Not of Münster.)
1851. „ „ Salter in Murchison's "Silurian Rocks of Scotland," Quart. Journ. Geol. Soc., vol. vii. p. 173.
1851. Orthoceras anellum, M'Coy in Sedgwick's "Geological Structure of the Frontier Chain, &c.," Brit. Assoc. Rep. p. 103. (Not *O. annellatum* of Hall.)
1852. Orthoceras bilineatum, M'Coy, 'Palæozoic Fossils,' p. 319. (Not of Hall.)
1857. „ „ Salter in Murchison's 'Siluria,' Foss. gr. 42, fig. 2.

Type.—The original specimen described by Portlock under this name is a surface fragment; the section is therefore unknown. The rate of increase is very slight, but incapable of measurement. The ornaments consist of rounded undulations with an obliquity of 3°, of such a character that their interspaces are simply re-entering angles; they tend to die away towards the larger end, and are distant $\frac{1}{3}$ the diameter. These are crossed by light longitudinal ribs, distant about $\frac{1}{6}$ the diameter, or half

their own distance; there are no intermediate ribs, but there were five transverse lines to each rib, as seen on the external cast. The septa are parallel to the ribs, and are therefore 3° oblique, and occupy the re-entering angle between them, and are therefore distant $\frac{1}{3}$ the diameter. The siphuncle is unknown. The diameter is $\frac{3}{4}$ inch. From the Lower Silurian Shales of Desertcreat. In the Museum of Practical Geology.

General Description.—The name adopted for this species belongs to a specimen which forms the most outlying member of a very variable group, the more typical members of which have been referred to various other species resembling, but not identical with this; hence the general idea of the species is rather different from that given by the specimen described as type. In none is the true form of section seen, all being elliptic by compression. The rate of increase in one example commences with being 1 in 9, but, with age, the rate decreases to almost zero; the rapidly expanding form, figured by Portlock, being contorted. No good characters of the body-chamber are observable. The ornaments consist of—first, transverse undulations, which are of very variable character, being sometimes wider than the interspaces, as in Portlock's type, sometimes narrower, as in the specimens figured on Plate III., but tending to become less acute and conspicuous with age; they are from 4° to 12° oblique, and occupy $\frac{1}{3}$ to $\frac{1}{5}$ of the diameter: secondly, a cancellation over the surface, varying in character with age. Up to a diameter of 8 lines there are longitudinal sharp riblets, about $\frac{1}{3}$ line apart, all, at first, of equal size, and with smaller intermediate ones, crossed by sharp transverse lines about 5 per line, but the latter, from the state of preservation, are not always visible, and even the intermediate longitudinal ones disappear; next the surface passes through an intermediate stage, in which the longitudinal riblets are in some places alternate, and in others in groups (fig. 5*a*), *i.e.* a larger one with several of irregular size between (fig. 9*c*), at the same time the transverse lines become more widely spaced, and divide the area into squares (fig. 9*b*); finally we get the form figured by Portlock, in which the larger longitudinals are clearly marked with three between each (fig. 9*a*), and the transverse lines are regular. These changes unfortunately have to be traced from specimen to specimen, but Portlock recognised the smaller ones as the young of his figured example, and they have the same general aspect. It is thus seen that Portlock's type represents a form in which all but the strongest longitudinal lines have died out, and these have become of more importance than the transverse ribs. The septa are in each hollow, cutting the upper slope of the rib in the middle, and are thus $\frac{1}{5}$ diameter apart. The siphuncle is apparently central. The greatest diameter seen is $1\frac{1}{2}$ inches.

Relations.—The various names that have been assigned to the specimens, here all referred to one species, show the great variability of that species, and this must be reckoned one of its characters. In Sowerby's *O. tubicinella*, from the Devonian, the

ribs are more direct, and the longitudinal ornaments are more regular and constant. In *O. calamiteum* the ribs are very rounded and the longitudinal lines very fine; and the same may be said of *O. bilineatum* of Hall, which might, however, be possibly included among the varieties of this. In *O. pseudo-calamiteum* the longitudinal lines are more delicate, sharp, and continuous, and the ribs are less oblique. On the whole, it is unfortunate that the more typical varieties should have received names that are not applicable; and if it should be proved that the type chosen does not really belong to the series, a new name would be required for the latter.

Distribution.—The great majority of the specimens come from the Bala Shales of Desertcreat (16); but one is also figured from beds of the same age at Ardwell, and the specimen referred by M'Coy to *O. bilineatum* comes from Girvan.

ORTHOCERAS VELATUM, Blake, Pl. III. figs. 12, 12*a*.

1865. ORTHOCERAS VELATUM, Salter, MS. Catalogue of Fossils in the Museum of Practical Geology.

Type.—The section is nearly circular, inclining to quadrate; the rate of increase is 1 in 18. No characters of the body-chamber are seen. The larger ornaments are gently undulating ribs, somewhat oblique and distant $\frac{1}{5}$ the diameter. These are covered by fine longitudinal and transverse riblets, each 18 per line, dividing the surface into square cancellations. The septa have a convexity of $\frac{1}{4}$ the diameter, and appear to cut the ribs on the upward slope. The siphuncle is moderate and central. The length is 2 inches, and the diameter more than $\frac{1}{2}$ inch. From Bala Limestone, Cynwyd. In my collection.

General Description.—The section, though generally compressed, is nearly circular in two or three instances, or at least equiaxial. The rate of increase in smaller examples is about 1 in 9, but decreases at the larger diameters. Some variation may be supposed in the ornamentation, due to distortion, preservation, and growth. The ribs can never be called separate; but even in those associated in the same beds with the type, they are, at times, almost acute, at others much less marked, and have a tendency, when highest, to imbricate downwards. They are probably always oblique, the maximum obliquity being 12°. Their distance in the smaller examples is $\frac{1}{4}$, but in the larger $\frac{1}{5}$ the diameter. The finer ornaments certainly change character somewhat in the length of the shell, the longitudinal lines being widest apart at first and ultimately getting much closer; some among them may become dominant, or, on the other hand, they may become so small as scarcely to be seen. Thus either one set or the other of these lines may prevail without the total absence of the other, or there being other characters that would justify a separation. In a curious specimen from Haverfordwest, which may belong here, the longitudinal lines are twice as numerous as the transverse, and quite subordinate to them. The septa, as seen in an example

from Coniston, are oblique with the ribs, and lie in the alternate interspaces, and have the same convexity as in the type. The siphuncle, also, is seen to be central and small. The greatest length seen is 2 inches; the greatest diameter, 14 lines.

Relations.—The statement that *O. ibex* occurs in the Lower Silurian is doubtless founded on examples of this species (M'Coy, 'Palæozoic Fossils,' p. 319). The ribs, however, have not here the separateness of those of *O. tenuiannulatum*, which is the species meant; and though in some the transverse lines are scarcely discernible, in other associated examples they are equal to the longitudinal, which is only the case in the young of M'Coy's species. Moreover the separation of the septa by two rings is a feature which unites the Cumbrian examples to those from Ireland. *O. discretum*, Barrande, from stage F, is very closely allied, but the ribs are much more pronounced and separate, and the cancellation is never equal in the two directions, while the rate of increase is less.

Distribution.—In the Bala Limestone of the Chair of Kildare (4); at Bala (1); and Cynwyd (3); and in Coniston Limestone (4). Also in the Lower Llandovery, Haverfordwest (2 ?).

Orthoceras Nicholianum, Blake, Pl. III. figs. 7, 7*a*; figs. 8 and 15.

Orthoceras Nicholianum, Salter, on tablet in Cardiff Museum.

Type.—The shell is now flattened in the stone, and the true section is therefore unknown, as is also the true rate of increase, which is slow. The ornaments consist of transverse, sharp, scarcely separate ribs, with an obliquity of about 5 degrees, and about $\frac{1}{6}$ the diameter apart. These are crossed by sharp, separate, longitudinal lines, which pass over the ribs, and slightly knot them at the crossing. They are irregularly placed, and not all of the same size; on the whole they are about three or four times as numerous as the ribs. Besides these, there are extremely fine transverse lines, five times as close as the longitudinal, and scarcely parallel to the ribs. The septa are not seen where the ornaments are preserved, which part may be the body-chamber; but at the smaller end are a series of small butt-shaped bodies, representing the apparently central siphuncle, and showing by their size that the distance of the septa was about $\frac{2}{3}$ line. The whole length seen is $3\frac{2}{3}$ inches, and the greatest diameter is 7 lines. From the Lower Ludlow of Usk. In the Museum of the Cardiff Naturalists' Society.

General Description.—This is a delicate shell, whose general appearance is perhaps better given by figs. 7 and 8, which may represent but one specimen, which shows a rate of increase of 1 in 14 on the flattened shell. The ornaments are always somewhat oblique, and are, when well preserved, acute and sub-separate, but may be rounded on the cast; they are from $\frac{2}{7}$ to $\frac{1}{5}$ the diameter apart. The minor

ornaments consist essentially of longitudinal, very sharp, raised lines, which vary in size on the same shell, and in some are very feeble, but in others almost rival the ribs,—they are usually two or three times as numerous as the latter; transverse lines in the interspaces may, or may not be, discoverable. Towards the aperture the stronger ornaments tend to die off. Other specimens show the septa to be close and of little convexity, and the siphuncle to be central. The type is almost the broadest specimen. The length was no doubt more than 6 inches.

Relations.—This species is certainly very close to *O. gracile*, though far less robust. The longitudinal riblets, however, are of a different character, being lamelliform and running evenly over the ribs, though less prominent between them. It is also in some respects similar to *O. dulce* (Barrande), if his variety *cœlebs*, with longitudinal riblets, is rightly included in that species; but the angular character of the ribs, and their obliquity, among other things, distinguish it from this, as also from *O. pseudo-calamiteum*, to which, at first, I referred the specimens.

Distribution.—In the Upper Llandovery, Llandovery (1); in the Wenlock Limestone of Dudley (2), Sedgeley (1), and Malvern (1); in the Lower Ludlow of Ledbury (1), and of Usk (4); and in the Upper Silurian rocks of the Pentland Hills.

Orthoceras annulatum, Sowerby, Pl. IV. and Pl. VIII. fig. 4.

1818. Orthoceras annulatum, Sowerby, 'Mineral Conchology,' pl. 133.
1839. „ „ Sowerby in Murchison's 'Silurian System,' pl. 9, fig. 5, p. 632.
1852. „ „ M'Coy, 'Palæozoic Fossils,' p. 319.
1852. „ „ Hall, 'Palæontology of New York,' vol. ii. pl. 29, 64, 65, pp. 96, 293.
1854. „ „ 'Siluria,' pl. 26, fig. 1.
1857. „ „ Boll, 'Archiv d. Ver. d. Freunde d. Natur, Mecklenburg.'
1860. „ „ Eichwald, 'Lethæa Rossica,' vii. p. 1229.
1867. „ „ Dixon, 'Woolhope Nat. Field Club, Fossil Sketches,' No. 1, fig. 5, p. 136.
1868. „ „ Barrande, 'Syst. Silur. de Bohême,' pl. 290, 291, p. 308.
1870. „ „ Barrande, loc. cit., pl. 441, figs. 2–5 (not fig. 1).
Syn. 1826. Orthoceras undulatum, Hisinger, 'Vetensk. Acad. Handlingär,' tab. vii. fig. 8.
1831. „ „ Hisinger, 'Anteckn. V.' tab. 4, p. 6.
1837. „ „ Hisinger, 'Leth. Suecica,' p. 28, tab. 10, fig. 2. (Not *Orthoceras undulatum*, Sowerby.)
Not 1836. Orthoceras annulatum, Phillips, 'Geol. Yorks.' vol. ii. pl. 21, figs. 9, 10, p. 239.
1837. „ „ Hisinger, 'Leth. Suecica,' p. 29, pl. 9, fig. 8.
Query 1838. Orthoceras attenuatum, Sowerby, 'Silurian Syst.' pl. 13, fig. 25, p. 632. (Not of Fleming.)
1849. „ subattenuatum, D'Orbigny, 'Prodrome.'

Type.—The original specimen of Sowerby was said by him to come from the

Carboniferous Limestone of Coalbrookdale, and it has therefore been supposed by many to be a Carboniferous species, and that the Silurian form must be a different one, though its identity was persisted in by Sowerby. It is to be noted that Prestwich, in his paper " On the Geology of Coalbrookdale," records the species from the Wenlock Limestone and other Silurian rocks of the district, and not from the Carboniferous. Moreover, in the index of localities appended to the 'Mineral Conchology,' it is stated to come from the Wenlock Limestone. An examination of the type specimen, now in the British Museum, confirms the identity of the common Silurian species with it. The section is elliptic, the ratio of the diameters being as 11 to 12. The rate of increase of this portion is 1 in 11. The whole is apparently body-chamber, which has therefore a length of four times its basal diameter. The aperture is not accurately seen, but is apparently quite simple. The ornaments are:—first, rounded, separate ribs, with wider, slightly concave interspaces; these are oblique about 3° on the narrower side, and so undulate on the broader, and are distant $\frac{1}{5}$ the diameter; at a distance of $\frac{5}{8}$ inch from the aperture these ribs suddenly cease: secondly, a number of elevated fimbriated riblets parallel to the ribs; 5 are crowded on the summits of the ribs, and 8 occupy the interval; they are not conspicuously grouped so as to form longitudinal bands, but their breadth is about $\frac{1}{2}$ the distance of the ribs; the concavity of the festoons is very feeble. The only septum seen lies in the interspace of two ribs, and is parallel to them; the convexity of the septal surface is $\frac{1}{4}$ the long diameter. The siphuncle is nearly $\frac{1}{3}$ the diameter of the shell, and lies on the shorter diameter, $\frac{5}{11}$ of its length from the side towards which the ribs and septa slope back; the form of its elements is not seen. Length, 4 inches; smaller diameter, 1 inch.

General Description.—The section of this truly variable species is certainly sometimes circular, at others it is a little quadrate, but usually is found having unequal diameters; the extreme ratio, without obvious compression, being 11 to 13. No curvature has been observed. The rate of increase is seldom so great as in the type, generally varying from 1 in 10 to 1 in 14, and often becoming much less rapid in the body-chamber. The latter is very seldom certainly observable; in one it reaches a length of $5\frac{1}{2}$ inches and a compressed diameter of $2\frac{1}{2}$ inches, without showing any signs of the aperture. Of the ornaments, the transverse ribs are of very varying character, but always present in the true species. Sometimes they are extremely elevated and have a tendency to imbricate backwards (fig. 5); sometimes they are the feeblest possible undulations of the surface (fig. 6), but ordinarily they are rounded and separate, as in the type. The interspaces are concave and wider than the ribs: these are generally undulating on the broader side, but often look quite direct, as seen; they vary in distance from $\frac{1}{8}$ to $\frac{1}{5}$ the diameter when uncompressed, but in flattened examples they may appear much closer. The feebleness of the ribs, though usually met with on large examples, is not always a

character of age; for some of the largest specimens have the strongest ribs, and the sudden change seen in the type is not repeated in any known British example. The transverse festooned riblets are, when well preserved, upright lamellæ; the portions which are concave to the aperture are much wider than the other portions; in distance, and relation to the longitudinal elevations, they are very variable, generally they are most marked when fewest in number. They are more crowded on the ribs than in the interspaces, and the more usual numbers are from 7 to 9, the lowest being 6 and the highest 18, for each rib and interval; the breadth of the festoons is from $\frac{1}{2}$ to $\frac{1}{4}$ the rib interval, more frequently the latter. There are occasionally fine parallel striæ between these riblets. Sometimes rounded, longitudinal, low elevations are developed, especially between the ribs; the relations of the festoons to these are very variable: sometimes the part which is convex to the aperture lies on the elevation, sometimes between: sometimes the regular succession of the festoons gives a false appearance of longitudinal lines, and occasionally there is no sign of them. In addition to these ornaments, one example shows bands of colour (fig. 4). It is an example in which the fimbriating riblets are numerous, 15 per space, very feebly festooned and showing no signs of any longitudinal elevation. On one side of it are bands $\frac{1}{8}$ inch broad, alternately light and dark, running in a longitudinal direction. The ornaments of the exterior do not appear to invariably mark the internal cast, but sometimes to leave it nearly unribbed. The septa cut the surface on the upper slope of the ribs, and thus are dependent on them for their distance, &c.; the convexity of the septal surface in the type is a maximum, it is usually less, and the septa are of the ordinary shape. One specimen (Pl. VIII. fig. 4), of two septal chambers without external surface, which would seem to belong to this species rather than to any other, shows a curiously conical form of septal surface. The siphuncle, when seen, is usually central, but it occasionally approaches one side, as in fig. 8. It does not increase in size at the same rate as the shell, so that it has a smaller proportion to the diameter in larger examples, the average being from $\frac{1}{5}$ to $\frac{1}{6}$; it expands but slightly between the septa to about $\frac{1}{4}$ the diameter, and is cylindrical in shape. The longest seen is 13 inches, and the greatest diameter $2\frac{1}{2}$ inches.

Relations.—The peculiar features of this species are so well marked, that the only question is whether its variability is sufficient to admit within its limits the forms called *O. fimbriatum;* the negative of this will be maintained under the heading of the latter. With regard to *O. attenuatum*, for which, if it be a true species, a new name would have to be invented, as its present one is pre-occupied, though the type is said to be in the Ludlow Museum, it is no longer to be found there, and I have been unable to discover it. As no description is given of it by Sowerby, and the drawing is at second-hand, and no specimens have been found elsewhere that would match better with that figure than with any other, I conclude it belongs to some known

species, and most probably to our present one, of which it would be a valuable example, the nearest approach to it being the specimen represented by fig. 7.

Distribution.—The examples of this species from the Bala Series of Sholeshook (4), as seen in the Museum of Practical Geology, and of Owens College, Manchester, are perfectly characterised, and leave no doubt of its existence during the Lower Silurian period. The example recorded by Salter ('Camb. and Sil. Foss.' p. 90), from the May Hill Sandstone, may belong to *O. ibex.* Throughout the Upper Silurian it is abundant, though more characteristic of the Lower beds. It occurs first in the Upper Llandovery of the Onny river (1); then in the Woolhope Limestone of Old Radnor (4), Littlehope (1), and Usk (1); in the Wenlock Shale of Barr (1), Cheney Longville (2), Malvern (1), Onny river (1), Usk (1), and Dennydd fawr (1); in the Wenlock Limestone of Dudley (11), Hay Head (2), Ledbury (9), Malvern (7), Wenlock (5), Coalbrookdale (4), Walsall (1), Eastnor (2), Usk (2), and Cardiff (1); in the Lower Ludlow of Ledbury (4) and Trecastle (2); and from the Upper Ludlow of Much Marcle, there is a specimen in Dr. Grindrod's collection, which may be this or an *O. ibex.* I have also seen four examples from the Upper Silurian rocks of Kerry, but have not met with it as a Scotch fossil.

In addition to these, the species has been recorded by Murchison from the Bala Beds at Llandovery; by M'Coy from Coniston Limestone; by Salter from the Upper Llandovery of Craig Nir; by Dixon, from the Woolhope Limestone, Scutterdine; by Murchison, from Upper Silurian, Presteign; by Phillips, from Haverfordwest, Llandeilo, and Abberley; by Sedgwick, from the Denbigh Flags; by Salter, from the Woolhope Limestone of Barr, from the Lower Ludlow of Parkes Hall, and from Upper Silurian of Croagh-Martin; and by Harkness, from the Balmae Schists, Kirkcudbright.

Out of the British Isles, this species is recorded by Eichwald from the Lower Silurian of Russia, and by Schmidt from the Upper Silurian of the same country. In Sweden it has long been known by Hisinger's figures, as an Upper Silurian fossil. Barrande finds it widely spread throughout his third fauna, it being about the only Bohemian species he admits to be identical with those of any other country. It is recorded also by Hall, from the Niagara and Clinton groups of New York; and from the former group in Wisconsin and Illinois. It is thus the most widely distributed Silurian Cephalopod both in time and space.

Orthoceras Duponti, Barrande, Pl. V. figs. 1, 1*a*, 2, 2*a*.

1868. Orthoceras Duponti, Barrande, 'Syst. Sil. de Bohême,' pl. 285, &c., p. 324.
Syn. 1873. Orthoceras subannulare, Salter, 'Camb. and Sil. Fossils,' p. 98.

Type.—The section is circular and the shell always straight. The rate of increase is 1 in 10. The body-chamber is 4 times the length of its basal diameter.

The aperture is slightly inclined in the direction of the ornaments, and there is a constriction below it. The ornaments change with growth. In the earlier part of the shell they are rounded, low rings, wider than the interspaces, 8° oblique, and distant $\frac{1}{5}$–$\frac{1}{6}$ the diameter; at a certain period of life, long before the septa have ceased to be formed, these rings disappear rather rapidly and very completely. These larger ornaments are covered by sharp, upright parallel riblets, about 14 in the space of a rib; these are continued after the ribbing has ceased, and disappear themselves at last. The septa are direct, and quite independent of the ornaments; their distance is exceedingly variable, rapidly changing from $\frac{2}{3}$ to $\frac{1}{3}$ the diameter, and their convexity decreases at the same time. The siphuncle is $\frac{3}{5}$ across the diameter, its own diameter is $\frac{1}{5}$ the same on the septal surface, and its elements are slightly inflated. The longest fragment seen is 8 inches, and its diameter 2 inches. It occurs chiefly in the band E_1, but also in E_2 of the Upper Silurian.

General Description.—It is obvious that both smooth and ribbed fragments may equally belong to this varying shell, but a reference to it will only be justified when one is seen passing into the other. The most characteristic example is that figured in fig. 1. It is flattened, and so the section and true tapering are unknown; the latter appears to be 1 in 6; at the lower end there are low undulations, irregular in size and distance, on the average $\frac{1}{7}$ the flattened diameter, and 8° oblique; these are seen entirely to die away for $1\frac{1}{2}$ inches, though the septa have not ceased. In the other example figured the ribs are direct; but as all other characters agree, this difference may be due to the directions of the compression. The whole is covered by sharp, upright riblets, from 9 to 15 to each rib space, which are continued after the cessation of the ribs. The septa are direct, have a considerable convexity, and the siphuncle is nearly central. The greatest length is more than 6 inches by $\frac{3}{4}$ inch diameter; one example shows the shell to have been broken and restored during life.

Relations.—The younger portions of these shells might very well be referred to Münster's *O. subannulare*, as far as his description goes, but that name has been restricted, after Barrande, to those with less numerous upward imbrications, the riblets in these being uniform and upright. It is thus to the present species rather than to Münster's that the specimens referred to by Salter, and partly by M'Coy, should be referred. Another difference between the two is that in *O. subannulare* there is not so great a change in the characters towards the aperture. From *O. dulce* this differs by the low, merely undulating character of its ribs. Nevertheless it is by no means impossible that those with more direct and more clearly marked ribs ought to be referred to the latter species.

Distribution.—In the Wenlock Shale of Carneddau, Builth (1); in the Lower Ludlow of Ledbury (3), Aymestry (1), Leintwardine (1), Elton (3), Dudley (3), and Wenlock (1).

ORTHOCERAS SUBANNULARE, Münster, Pl. V. figs. 6, 6*a*.

1840. ORTHOCERATITES SUBANNULARIS, Münster, 'Beitr.' iii. pl. 19, fig. 3, p. 99.
1852. ORTHOCERAS SUBANNULATUM, M'Coy, 'Pal. Fossils,' p. 320 (part).
1866. „ SUBANNULARE, Barrande, 'Syst. Sil. de Bohême,' pl. 283, &c., p. 343.
1873. „ „ Salter, 'Cambrian and Sil. Foss.' p. 159 (not p. 98).

Not 1843. ORTHOCERAS SUBANNULARE, Portlock, 'Geol. Rep.' pl. 25, fig. 78.

Type.—The figure and description of Münster show that the section is circular, the shell without any curvature, and the rate of increase 1 in 12. The ornaments are apparently direct rings, flatter and nearer together than in *O. annulatum*, at the smaller end about $\frac{1}{4}$ and at the larger end $\frac{1}{6}$ the diameter apart; the whole is finely "striated" transversely when the shell is preserved. The septa have considerable convexity, and the siphuncle is central. Length, $2\frac{1}{4}$ inches; diameter, $\frac{3}{4}$ inch.

General Description.—Although our British fossils agree with Münster's type, as far as the above characters are concerned, it is rather with the well-illustrated specimens of Bohemia that comparison must be made. Only one example shows any section, and in that it has been compressed. The rate of increase is consequently not to be ascertained. The ornaments are feebly-marked rings with narrower interspaces, which are direct, as seen, though Barrande describes and figures his as undulating; they are distant from $\frac{1}{15}$ to $\frac{1}{7}$ the flattened diameter. On these rings are a number of parallel riblets, which have a forward imbrication; they are about six to each ring, and on account of their direction are further apart on the posterior than on the anterior slope. Towards the aperture the rings become irregular and nearly die off, but indications of them may still be seen. No septal characters are perceived in any. Greatest length seen, $1\frac{1}{3}$ inches; greatest diameter, 1 inch.

Relations.—I fear there may be some confusion about this species, as Barrande's may not be the same as Münster's, and the latter may correspond more closely to those I have referred to *O. Duponti*. These slightly ribbed species, as their history is learnt from Bohemian examples, change their character in the adult, and are much alike when young; the distinguishing character of those collected under this name is the fewness and upward imbrication of their riblets, and their undulations are not entirely lost near the aperture. The British examples, however, are very badly preserved, and throw little light on their true nature. However, M'Coy recognised this species as occurring in Britain. It chiefly differs from *O. dulce* in the weakness of the ribbing.

Distribution.—In the Wenlock Shale of Builth (1) and in the Lower Ludlow of Dudley (?) (1) and of Usk (3), and possibly in the Coniston Flags of Coldwell (2).

Harkness and Nicholson also record this species from the Coniston Beds, Randy Pike, though the reference may, of course, be to *O. Duponti*.

ORTHOCERAS IBEX, Sowerby, Pl. V. figs. 3, 3*a*, 4, 5, 8.

1838. ORTHOCERAS IBEX, Sowerby in Murchison's 'Silurian System,' pl. 5, fig. 30, p. 613.
1867. „ „ Dixon, 'Woolhope Nat. F. Club, Fossil Sketches,' No. 1, fig. 2.
Syn. 1838. ORTHOCERAS ARTICULATUM, Sowerby, loc. cit., pl. 5, fig. 31, p. 613.
1837. „ ANNULATUM, Hisinger, 'Leth. Suecica,' pl. 9, fig. 8, p. 29 (not of Sowerby).
1857. „ HISINGERI, Boll, 'Archiv für Mecklenburg,' vol. xi. pl. 5, fig. 13, p. 18.
1870. „ „ Barrande, 'Syst. Silur. de Bohême,' pl. 441, figs. 17–19, p. 700.

Not 1852. ORTHOCERAS IBEX, M'Coy, 'Pal. Fossils,' p. 319.
1852. „ „ Salter, 'Pal. Fossils,' App. A, p. vii.
1873. „ „ Salter, 'Camb. and Sil. Fossils,' p. 71, &c.
1838. LITUITES IBEX, Sowerby, loc. cit., pl. 11, fig. 6, p. 622.
1852. HORTOLUS IBEX, M'Coy, 'Pal. Fossils,' p. 324.

Type.—This is partly flattened, so that one diameter is nearly double the other; and the rate of increase is now 1 in 24 for the longer diameter. The ribs are subseparate in character, less than the intervening spaces, but rather rough; they are slightly undulating, and on the whole 5° oblique, and are distant $\frac{2}{7}$ the diameter. The specimen being a cast, the surface ornaments can be but ill made out, but the fact of the original riblets having been transverse is clear. No septal characters are seen. Length, 2 inches; greatest diameter, $\frac{2}{3}$ inch. From the Upper Ludlow, Malvern. In the Museum of the Geological Society.

General Description.—The minor ornaments being thus transverse in the type, and not longitudinal, as supposed by M'Coy and Salter, we must seek the further elucidation of the species among such as possess this character; and among them, in fact, we find examples agreeing better with the other features of the type. No examples referable to this species have been seen with more equal diameters than 7 and 5 lines, and it may therefore be naturally elliptical. No curvature is seen in any. The rate of increase in the septate portion appears always very small, but the earlier portions of the shell are seldom seen; the most rapid is 1 in 7, in an example so flattened that one diameter is double the other. In the body-chamber some changes appear to take place. Two examples (Pl. V. figs. 3, 4) which I cannot for any other reason separate from *O. ibex*, show a gradual diminution of diameter in the earlier part of the body-chamber, which extends in one of these to a distance of five times its basal diameter, and no aperture is indicated. It is on the strength of this character that *O. Hisingeri* has been separated as a distinct species by Boll and Barrande (loc. cit.); but it is exceedingly unsatisfactory to have such a character alone as a discriminant. The majority of body-chambers show that at the termination the diameter is increasing, and I think there is proof that the contraction takes place in the middle, and not at the end of the body-chamber (see fig. 4), and these contracting examples belong to its lower half, in which case it must have been of

extreme length, viz. about ten times as long as its basal diameter, and this will account for the numerous examples showing no trace of septa. The aperture is simple, parallel to the ribs, and without contraction or expansion. The ornaments consist of rounded or subangular, characteristically separate ribs, showing some tendency to imbricate downwards; these are distant in very varying proportions, ranging from $\frac{1}{3}$ to $\frac{2}{9}$ the longer diameter; the distance is seen to change in the length of a single specimen, being least at the base of the body-chamber; they have an obliquity amounting in some to 10°: that this is sometimes seen on the broader side, and sometimes is only indicated there by the undulation of the ribs, is due to the different directions of compression. The surface, when well preserved, has numerous sharp transverse lines parallel to the ribs, generally too fine to count: these are often absent, and are considered in that case to have been worn away: among such are the two contracting body-chambers; but no longitudinal lines are ever seen in those referred to this species. Towards the aperture, as seen in some examples, the ribs die away over a distance of about 2 inches, the last preserved becoming enfeebled, but the finer lines continue over this surface. In none of the specimens examined, which show this change on approaching the larger end, do any septa appear at the smaller, and in one (fig. 4) there are 5 inches without any septa being seen; hence these specimens, except the last, may be considered as showing only the final half of the body-chamber. The septa, when seen, lie in the hollows between the ribs, one to each; but the septum is not quite parallel to, but more direct than, the ornaments; the surface has a convexity of $\frac{1}{5}$ the corresponding diameter. The siphuncle, of moderate and uniform size, lies on the long diameter, at a distance of $\frac{2}{5}$ of that line from the side to which the ribs slope back. The greatest length seen is $7\frac{3}{4}$ inches, and the long diameters are from $9\frac{1}{2}$ lines to $4\frac{1}{2}$ lines. The specimens from the north of England have a greater angularity and more obliquity in the ribs than those from the typical Silurian districts, but differ in no other respect. The rapid expansion seen in fig. 5 is noticeable, as it is a feature which seems to be commoner in this species than in any other, and on this ground we may refer to two curious examples—one from the Wenlock Limestone, and the other from the "Upper Llandovery" beds of Shallallymore—in the Museum of Practical Geology, which show a very sudden change, the upper part being at the same time almost ribless.

Relations.—The character of the ribbing, especially in southern examples, agrees with that of *O. tenuiannulatum* in being rounded and separate, but the finer ornaments are transverse. Those examples which show none of these are placed with the present species, on account of the greater ease with which transverse lines may be lost. From *O. tracheale* this differs by the obliquity of its ribs, and from *Cyrtoceras ibex*, by its want of curvature. The *O. Hisingeri* of Boll, founded on Hisinger's *O. annulatum*, was identified by Sowerby as belonging to his species, and my

observations do not enable me to separate them. Small examples of this species do not show the crinoid aspect of *O. kendalense*, and they are therefore considered distinct. The observation of the fact that Sowerby's type has transverse lines rids us of much difficulty in the discrimination of this and allied species.

Distribution.—Examples have been examined from the Wenlock Shale, Dinas Bran (1); from the Coniston Grit, Howgill Fell (2); from the Lower Ludlow of Ledbury (2), Mocktree (1), and Shelderton (1); from the Upper Ludlow of Benson Knot (5), Kendal (1), Ledbury (2, one of which shows the contracting body-chamber, and the other the loss of ribs), Malvern (7), of Ludlow (3), of Builth (1), and of Usk (4). Sowerby's *O. articulatum*, which I have not seen, is from the Upper Ludlow, near Aymestry. An external cast, with the ornaments of this species rather exaggerated, but with a rate of increase in the apparently uncompressed shell of 1 in 6, and with an elliptic section, occurs in the Lower Silurian rocks of Waterford; another in Tipperary, and a doubtful form in the May Hill Sandstone. Some of these may, perhaps, belong to *O. Grayi*, or to some species as yet undefined.

Specimens referred to this, but of which there are no means of knowing whether this species, *O. tenuiannulatum*, or *O. tracheale* are intended, are recorded by Phillips from the Wenlock Shale of Llandeilo, May Hill, Woolhope, and Abberley; by Lapworth from the Wrae Limestone and Riccarton Beds; in the Catalogue of Western Scottish Fossils from Ardmillan Braes; by Sedgwick from Upper Ireleth Slates, Howgill, and from the Coniston Grits; by Strickland from the Upper Ludlow of Hagley, and by Salter from the same at Coalbrookdale. Other references under this head are either obviously to longitudinally ornamented species, or to examples in Lower Silurian rocks, in which this has not as yet been proved to occur. On the Continent it occurs, of course, in Gothland.

ORTHOCERAS TRACHEALE, Sowerby, Pl. V. fig. 7.

1838. ORTHOCERAS TRACHEALE, Sowerby in Murchison's 'Silurian Syst.' pl. 3, fig. 96.
1851. „ „ M'Coy, 'Pal. Foss.' p. 321.
1854. „ „ Salter in Murchison's 'Siluria,' pl. 34, fig. 6.
Query 1848. ORTHOCERAS PERELEGANS (part), Salter, 'Mem. Geol. Survey,' vol. ii. pl. 13, figs. 2, 3 (not fig. 4).

Type.—The specimen figured by Sowerby is merely a short hollow cast in the usual Tilestone flag. It shows that the section was nearly circular, and the increase probably slow. The ornaments would be acute, scarcely separate, nearly direct ribs, $\frac{2}{7}$ the diameter apart. These are covered by parallel sharp riblets. The septal surface at the end is rather flat. From the Tilestone of Horeb Chapel, Trecastle. In the Collection of the Geological Society.

General Description.—The section in well-preserved examples (fig. 7) is circular,

and the rate of increase is 1 in 12. There is no curvature whatever. The ornaments are acute ribs, though rather rounded in the cast; they are scarcely separate, are quite direct, and distant $\frac{1}{3}$ to $\frac{2}{7}$ the diameter apart. When well preserved, there are sharp riblets parallel to the ribs, somewhat imbricating downwards. The septa are parallel to the ribs, and lie in the interspaces; their convexity is very small, indeed they are remarkably flat. The siphuncle is small, and nearly, if not quite, central. The greatest diameter seen is $\frac{1}{2}$ inch, and the length $2\frac{2}{3}$ inches.

An example which agrees with this in all respects, except in having a greater convexity of septum than usual, shows the characters of the body-chamber. It is twice the length of the basal diameter, and contracts notably towards the aperture. The last four ribs are also crowded into a much smaller space.

Relations.—It may seem doubtful whether two species so similar to each other as *O. ibex* and *O. tracheale* can be retained: still it must be admitted that there are great differences between such forms as fig. 5 and fig. 7, though figs. 3 and 4 may be somewhat intermediate. The chief difference is in the directness of the ribs in *O. tracheale*, which was apparently made the basis of Sowerby's original separation. We cannot rely on the acuteness of the ribs, unless we are prepared to multiply species, for either form of rib appears possible in each without introducing other distinctions. Both these species are essentially straight, and have no relation to the curved forms with which they have been confounded, as may be seen at once by an inspection of fig. 10 compared with figs. 5 and 7. *Orthoceras perelegans* is a name for which there is no room after the proof of the transverse ornaments of both this and *O. ibex*.

Distribution.—In the Lower Ludlow of Mocktree (1) and Aymestry (3); in the Upper Ludlow of Llandovery (1), Ludlow (7), Richard's Castle (1), and Usk (4); in the Tilestones of Trecastle (2), and from the Upper Silurian of the Pentlands.

M'Coy also records it from Ludlow Beds at Kendal, Llangollen, and from the Wenlock Shale at Sedbergh. Phillips records it from Llandeilo; and Lapworth and Wilson from the Riccarton Beds. There are specimens from the Lower Ludlow of Ledbury (5) and Dudley (1), which seem to differ from this only by the septa corresponding to the ribs, but they may really belong to *O. Grayi.*

ORTHOCERAS TENUIANNULATUM, M'Coy, Pl. V. figs. 9, 9*a*.

1851. CYCLOCERAS TENUIANNULATUM, M'Coy, 'Ann. Nat. Hist.' Ser. ii. vol. vii. p. 45.
1852. „ „ M'Coy, 'Palæozoic Fossils,' pl. 11, fig. 31.
1873. ORTHOCERAS TENUIANNULATUM, Salter, 'Camb. and Silur. Fossils,' p. 173.
Syn. 1852. CYCLOCERAS IBEX, M'Coy, 'Pal. Foss.' p. 319 (part).
— ORTHOCERAS IBEX, Salter, 'Pal. Foss.' Appendix A, p. vii. (Not of Sowerby.)
1854. „ VERTEBRALE, Morris, 'Cat. Brit. Foss.' p. 312. (Not of Hall.)

1873. ORTHOCERAS IBEX, Salter, 'Camb. and Silur. Foss,' p. 186.
Query 1865. ORTHOCERAS TENUIANNULATUM, Haswell, 'Silur. Foss. of Pentland Hills,' pl. 1, fig. 3, p. 25.

Type.—The section is now flattened, so that the radii are as 1 to 3. Its rate of increase in the longer diameter is 1 in 16. No signs are here given of the body-chamber, the form of the aperture, the septa, or the siphuncle. The ornaments are :—first, very clearly separated rounded ribs, the interspaces being wider than they, and but slightly concave; these are nearly direct, having a slight concavity towards the aperture on the broad side, and are distant $\frac{1}{5}$ the flattened diameter: secondly, there are fine longitudinal raised lines, 20 per line, and at the smaller end the tops of the ribs have two or three transverse lines. The large ribs die off for about $\frac{1}{2}$ inch from the larger end, leaving only a striated surface. The greatest diameter (compressed) is $\frac{1}{2}$ an inch; the length seen is 2 inches. From the Lower Ludlow of Aymestry. In the Woodwardian Museum.

General Description.—It is probable that the true section was slightly elliptic, as one example, apparently uncompressed, has that form; they are mostly, however, found with very unequal diameters. There is not the slightest curvature in any example; and if some small ones are rightly included, we see almost to the commencement. The rate of increase, even in the most compressed, is never greater than 1 in 9, more usually 1 in 14, but varying down to zero. No characters of the body-chamber or of the aperture have been seen. The ornaments are always the characteristic ribs of the type, occasionally a little more acute than usual; they are generally direct, but a maximum obliquity of 5° may be present. On larger specimens they are distant $\frac{1}{3}$ to $\frac{1}{4}$ the diameter; but at the smaller end they are closer, and may, by compression, be only $\frac{1}{5}$, or even a less fraction of the diameter apart. The longitudinal riblets vary chiefly with the diameter; generally they are 12 to 14 per line, but, as in the type, they may be more numerous, or at a large diameter reduce to 5 per line. No transverse lines are seen in most, but the smaller ones have some on the ribs, and a few small examples agreeing with this in every other respect, which may be assumed (for certain proof is wanting) to be the young, have an equal close cancellation, the transverse lines not being quite parallel to the ribs. Towards the aperture the larger ornaments give way to irregular ridges of growth. The septa are seen in two examples to lie in each interval between the ribs, but no further details are observable. The greatest diameter is 13 lines, and the greatest length seen is $2\frac{3}{4}$ inches. An example of this species shows, by the arrangement of its surface ornaments, that the shell was broken and repaired during life.

Relations.—This species is well characterised by the longitudinal finer ornamentation and the separateness of its ribs. Salter, in the second volume of the 'Memoirs of the Geological Survey,' first stated that the *O. ibex* of Sowerby had

longitudinal riblets, by which he would distinguish it from his *O. perelegans.* Sowerby, however, himself says nothing about them, and an examination of his type has failed to show me any, though specially looking for them. Moreover, the general character of the ribs is not the same. While, therefore, I agree with Salter in recognising only one longitudinally ornamented species, I cannot call it *O. ibex.* M'Coy, describing some examples with longitudinal riblets as *O. ibex*, including Lower Silurian forms of different character, gave the present name to those "with narrower and more sharply defined rings, considerably more numerous, and with finer longitudinal striation." However, *all* the longitudinally marked specimens that I have seen have the same narrow character of ribs. I conclude there is only this one longitudinally ornamented species in the Upper Silurian, and all those called *O. ibex* on account of such ornament probably belong to it. No *Orthoceras* with this kind of ornament appears among Barrande's numerous Bohemian forms. The *O. vertebrale* of Hall has angular ribs, and is much larger, while it retains the transverse striation. The cancellated young forms referred to this species have no satisfactory distinction in themselves from *O. velatum*, and might be taken to prove the presence of the latter in Upper Silurian rocks. My interpretation, however, seems the more probable one.

Distribution.—Examples have been examined from the Upper Llandovery, Penlan (1 large); from the Lower Ludlow of Aymestry (2), Mocktree (8), View Edge (1), Dudley (3), and Ledbury (1); and from the Upper Ludlow of Mocktree (1), Usk (1), Ludlow (2), Kendal (1), Bircher Common (1), and Builth (1).

Haswell (loc. cit.) records a species under the name as found in the Upper Silurian of the Pentlands.

ORTHOCERAS KENDALENSE, Blake, Pl. III. figs. 13, 13*a*.

Type.—The section was perhaps originally elliptical, the ratio of the axes being now as 11 to 8. The rate of increase of the longer diameter is 1 in 11. The ornaments consist of subangular ribs, *i.e.* of ribs which on reaching the lowest level begin at once to rise again, and are not very rounded on their summits. These have an obliquity of 6°, and are distant $\frac{2}{9}$ the longer diameter. No finer ornaments are preserved. The septa lie in each hollow, and are therefore 6° oblique, and distant $\frac{2}{9}$ the diameter. Their convexity is about $\frac{1}{4}$ the diameter, and their surface retains its vascular markings. The siphuncle is as nearly as possible central. The length is 11 lines, and the diameter $4\frac{1}{2}$ lines. From the Upper Ludlow, Kendal. In the Museum of Practical Geology.

General Description.—The nearest approach to a circular section seen is in one whose diameters are as 11 to 10, and in this the rate of increase is 1 in 10 ; but the more flattened examples seem to have a less increase almost down to zero. As the

ornaments characteristic of the type appear to be those of the young shell, and afterwards to change, the character of the body-chamber and aperture will have to wait the discovery of some connecting specimens. These ornaments are very peculiar, giving the appearance of a crinoid; but in two examples showing them at one end we find them changing with growth into a more rounded separate type. They are generally oblique, as seen on the side, but appear undulating only when seen on the ventral or dorsal surface, and vary in distance between $\frac{1}{4}$ and $\frac{1}{5}$ the diameter. They are covered superficially in one example by 28 sharp transverse riblets per interval. The septa are at the base of every interval, and are almost always seen; they are parallel to the ribbing, and their convexity is not more than $\frac{1}{4}$ the diameter. The central siphuncle is also confirmed in other examples. The greatest diameter at which these features are exhibited is 7 lines.

Relations.—This species differs from *O. ibex* in the character of its ribs and their greater closeness. It differs from *O. adornatum* in the latter characteristic alone, but then the difference is great. It is with great doubt that I separate this from *O. Gothlandicum*, Boll, 'Archiv für Mecklenburg,' pl. 5, fig. 14, and Barrande, 'Syst. Sil.' pl. 441, fig. 14, with which it agrees in the shape of its ribs and its general form, and differs only in having a central siphuncle and its ribs more remote, being thus related to *O. ibex* as *O. Gothlandicum* is to *O. dulce.*

Distribution.—In the Upper Ludlow of Kendal (2) and of Llechclawdd (1); in the Aymestry Limestone of Usk (3), and in the Lower Ludlow of Mocktree (1). Also in the Upper Ludlow of Ludlow, showing the ribs of angular character changing into more separate ones, with the transverse riblets (1).

ORTHOCERAS ADORNATUM, Barrande, Pl. III. fig. 10.

1870. ORTHOCERAS ADORNATUM, Barrande, 'Syst. Sil. de Bohême,' pl. 353, figs. 7–9, p. 299.

Type.—The section is circular, and the rate of increase is 1 in 18. The shape of each septal chamber is such that the centre swells out into a subangular band, with nearly flat slopes to the sutures: these are direct, and distant $\frac{1}{2}$ the diameter apart. The surface of each chamber has about 10 transverse lines. No siphuncle is seen. The length is 2 inches, and the greatest diameter is $4\frac{1}{2}$ lines. It is the only specimen known, and is found in the band E_1 of the Upper Silurian.

General Description.—A solitary example in the Museum of Practical Geology repeats these features very exactly, though the section is not seen, and the rate of increase is, if possible, less; the transverse riblets are not seen. The length is about 1 inch. and the diameter about $\frac{1}{4}$ inch.

Relations.—This differs from *O. tracheale*, to which it has been referred in the Museum Catalogue, by the wide separation of its septa, and the angular character of

its rings. This last character is repeated in *O. kendalense,* but in that the septa and rings are closer still. Both one and the other specimen leave a doubt upon one's mind whether they may not rather be Crinoids than Cephalopods.

Distribution.—In the Ludlow Passage Beds, Newton Lane, Kington (1).

ORTHOCERAS GRAYI, Blake, Pl. XIII. fig. 6.

Type.—The section is elliptic, the diameters being in the ratio of 5 to 4. The rate of increase of the long diameter is 1 in 5. The whole is septate. The ornaments are sub-acute, sub-separate ribs, 2° or 3° oblique on the narrow side, $\frac{2}{9}$ the long diameter apart. The specimen is too rough to show any finer ornaments, if they existed. The septa are oblique in the opposite direction to the ribs, and to about the same amount; they are closer than the ribs, being about $\frac{1}{6}$ the long diameter apart. The siphuncle is not well seen, but appears to be central. Length, $1\frac{3}{4}$ inches; greatest diameter, 1 inch. From the Wenlock Limestone, Dudley. In the Gray Collection in the British Museum.

General Description.—No example but the type shows the characteristic relation of the septa to the ribs; but as there are specimens agreeing with this in outward features, associated in the same locality, and not belonging to other known species, it may be assumed that they belong to this. No section is seen in them, and the rate of increase is much slower, not being more than 1 in 10, in a larger though flattened example. The ribs are in one $\frac{2}{9}$ and in another $\frac{2}{7}$ the diameter apart, slightly oblique on the narrow side, of the separate semi-acute character, and covered in two examples with fine parallel riblets. These have diameters of more than 1 inch. Still larger examples, possibly of this species, show very strong ribs, and the riblets are upward imbrications.

Relations.—The peculiar septal characters which are uncommon in *Orthocerata,* belonging to this group, immediately separates the type from other species, though a want of parallelism between the septa and ribs, in some examples referred to *O. ibex,* leads us towards such peculiarities. When the surface only is seen, the chief distinguishing features are the rate of increase and the large size. The absence of any festooning in the finer ornaments separates this externally from *O. annulatum.*

Distribution.—In the Wenlock Limestone of Dudley (4). Examples of this species are in the British and Woodwardian Museums. There are also two specimens from the Lower Ludlow of Ledbury (2) in the collection of Dr. Grindrod, which only differ from *O. annulatum* in the transverse riblets showing no sign of festooning, and which may therefore more probably belong to this species.

ORTHOCERAS DIMIDIATUM, Sowerby, Pl. VI. figs. 11, 12.

1839. ORTHOCERAS DIMIDIATUM, Sowerby in Murchison's 'Silurian System,' pl. 8, fig. 18, p. 620.
1852. " " M'Coy, 'Pal. Foss.' p. 314.
1852. " " Salter, Appendix A to 'Pal. Foss.'
1873. " " Salter, 'Camb. and Sil. Foss.' pp. 98, 173.
Syn. 1848. ORTHOCERAS SUBDIMIDIATUM, D'Orbigny, 'Prod.' vol. i. p. vii.

Not 1841. ORTHOCERAS DIMIDIATUM, Münster, 'Beit.' vol. iii. t. 19, figs. 3–5.

Type.—No section is seen. The rate of increase is 1 in 18. No characters of the body-chamber are seen. The ornaments are semi-ribs, found only on the right side of the specimen; these are slightly undulating, but slightly oblique, rising to the left side; they are $\frac{1}{7}$ the mean diameter apart, and consist of downward imbrications which gradually die away. There may have been finer lines parallel to them. The septa are obscurely seen on the unribbed side, about $\frac{1}{2}$ the diameter apart and nearly direct. Length, 2 inches; diameter, $\frac{1}{4}$ inch. From the Lower Ludlow, Radnor Forest. In the Museum of the Geological Society.

General Description.—The specimens which certainly belong to this species are all either external casts (fig. 10), or surface-markings only (fig. 11). The average rate of increase, as observed, is 1 in 16. The body-chamber is several times the length of its basal diameter. The aperture has a sigmoid outline passing into a forward curve on the unornamented side (see fig. 11). The ornaments can only be described as imbrications passing obliquely half across the shell, as it is impossible to dismember the species according to the minor varieties. With regard to the direction of the imbrication, it may be either upward or downward; but in two examples, one kind appears to change by degrees into the other. In most, the lower half of the ribs is preserved, but in some it is the upper. In the former case they lie on the ventral side, but in specimens of the latter the aperture has not been observed. These ornaments are generally oblique from 7° to 10°, but may be more so by distortion. Their distance is seen in one example to increase with age, being nearly twice as close at the small end; on the average they are $\frac{1}{6}$ the diameter apart. The septa are parallel to the ribs. The distance is not constant, but varies $\frac{1}{3}$ to more than $\frac{1}{2}$ the diameter. The siphuncle has not been seen. The greatest length seen is 3 inches; and the greatest diameter, 4 lines.

Relations.—Where compressed as usual so as to show the semi-ribs, this species is easily distinguished from all other British species; but it may be occasionally flattened so that the ribbed side only is exposed: it then resembles *O. subundulatum*, but the imbrications are stronger, more usually downward, and show some signs of decrease. Its representative in Bohemia appears to be *O. bifrons*, from which it differs in having stronger ornaments and more remote septa.

Distribution.—It occurs in the Coniston Flags of Helm Knot (1); in the Lower Ludlow of Kingston (4), Radnor Forest (1), and Leintwardine (2); in the Upper Ludlow of Brigsteer (1), and in the Upper Silurian on the west side of Caherconree, co. Kerry (6).

It is recorded by R. Etheridge, jun., from the Upper Silurian of the Pentland Hills, and in the Catalogue of Western Scottish Fossils from Old Red Sandstone (!), Carmichael Burn, Lanark.

Orthoceras Etheridgii, Blake, Pl. VI. figs. 3, 4, 5, 5*a*, 6, 6*a*.

Type.—The section is nearly circular, the ratios of the diameters being 18 to 17; the rate of increase for the longer diameter is 1 in 10. No details of the body-chamber or aperture have been observed. The ornaments consist of transverse impressed grooves, the bases of which are flat and the interspaces flat also, and three times the width of the grooves. These are undulating and oblique, 13° on the broader side, and at a somewhat inconstant distance, about $\frac{2}{15}$ the diameter, at the larger end. The septa are more direct than the ornaments, and have a convexity of $\frac{1}{2}$ the long diameter; their distance is $\frac{2}{5}$ of the same line. The siphuncle is about $\frac{1}{6}$ the diameter, and lies $\frac{2}{5}$ of the diameter from the side to which the ornaments slope back. The remarkable feature of this species is that, taking the place of the septal surface, there is a peculiar inflated surface which is more or less continuous with the outside of the shell; over the siphuncle and leading down to it is an elongated deep hollow, in the direction of the longer diameter; from this, radiating impressed lines or furrows proceed to the circumference, having the aspect of being produced by folds. The length is $7\frac{1}{4}$ inches, and the greatest diameter $1\frac{1}{2}$ inches. From the Upper (?) Silurian on the east side of Kirkcudbright Bay, where it was found by R. Etheridge, jun., after whom I have named it. In the Museum of the Geological Survey, Edinburgh.

General Description.—The other examples found at the same time and subsequently, by my friend R. Etheridge, jun., one of which he has had cut in a longitudinal section, confirm the remarkable features of the above. The section is not so nearly circular at the smaller end, but the rate of increase is pretty constantly as in the type. The grooves are seen to vary somewhat in their distance, the maximum being $\frac{1}{5}$ the diameter. The section shows that the siphuncle narrows at the junction of the septa and expands cylindrically in the chambers; the septal distance and convexity is confirmed, and it is seen that the surface which is exposed at the ends is not the septal surface; the latter are apparently smooth and the thickness small, and the short necks are seen to turn rapidly outwards from the siphuncle; above these is the dark deposit, whose exterior is exposed when the fossil becomes broken; this has a greater convexity than the septum, and is continuous in appearance with the exterior of the shell. Its occurrence in two or three chambers proves

that it is not a deposit formed after the smaller end of the shell is broken off. The number of small fragments which occur, consisting of one or more chambers with the characteristic ends, shows that the breaking off was not an uncommon circumstance, and very possibly took place during life. On the surface of these caps the deeper furrows lie on the side nearest to the siphuncle; they are generally median, but occasionally paired; on the other side are three or more lighter furrows, which occasionally bifurcate. It is difficult to conjecture the cause of these phenomena, which must have had their origin between the formation of one septum and the next. I can only suggest a shrinkage of the mantle during the interval, by which it was thrown into folds, which were perpetuated by an abnormal deposit on their surface. The type is the only large example seen; the rest are for the most part fragments, showing the ends.

Relations.—A fragment, figured by Barrande under the title *O. sarcinatum*, shows very similar features on a pseudoseptal surface. Though the fossil is of larger size, the section is more elliptical, the siphuncle more nearly central, and there is no great depression round it; the furrows are all paired, there being no median one; the surface of the shell is not described as showing any grooves. Though, therefore, the existence of a similar structure binds these two together, there is no proof that they are identical. The grooved surface is not to be matched in any British *Orthoceras* with which I am acquainted. The surface of *O. fasciolatum*, Barrande, is grooved, but the grooves are much closer in proportion, and the whole shell is smaller and more slowly tapering.

Distribution.—This species has only been found in the one locality near Raeberry Castle, on the east side of Kirkcudbright Bay, where it appears to be tolerably abundant. I have seen 14 examples.

ORTHOCERAS MACLARENI, Salter, Pl. VI. figs. 7, 8, 9, 10.

ORTHOCERATITE, Maclaren, 'Geol. of Fife and the Lowthians,' p. 203.
1854. ORTHOCERAS MACLARENI, Salter in Murchison's 'Siluria,' Foss. gr. 25.
1861. „ „ Salter, 'Mem. Geol. Surv. Scotland,' Sheet 32, p. 143.
1865. „ „ Haswell, 'Silurian Rocks of the Pentlands,' pl. 1, fig. 2, p. 23.
1873. „ „ Salter, 'Camb. and Silurian Fossils,' p. 186.

Type.—I have not seen any example which corresponds to the figure given in 'Siluria.' It appears to be compressed; the rate of increase is 1 in 6. No signs of any aperture are seen. The ornaments are "strong, sharp ridges, imbricating upwards;" these are irregularly spaced, but on the average are $\frac{1}{12}$ the long diameter apart. They are oblique on the broader side, about 9° in the figure. The septa are nearly direct, and $\frac{2}{9}$ the diameter apart. The length of the fragment is $1\frac{1}{8}$ inches, and the greatest diameter $\frac{3}{4}$ inch. From the Upper Silurian of the Pentland Hills.

General Description.—The diameters are not seen nearer to equality than the ratio of 18 to 13. The rate of increase is too variable to measure, but it is not greater than 1 in 14. The ornaments are peculiar; in the earlier portion they are really grooves with rounded edges, and from their abundance look like striæ, but as these become wider and closer the intervening parts take the character of almost sharp but not separate ribs, of great irregularity. They have an obliquity sometimes amounting to 12° in larger specimens, but appear to undulate only in small ones. Their distance is variable, from $\frac{1}{9}$ to $\frac{1}{16}$ the diameter, or even less; they have an irregular imbrication. The septa are direct, and have a convexity of $\frac{1}{3}$ the long diameter; they are distant $\frac{2}{7}$ the diameter: the last chambers appear to be closer than the rest; the siphuncle is central. The greatest length seen is $8\frac{1}{4}$ inches, and the greatest diameter $1\frac{1}{3}$ inches. I consider a number of small specimens coming from the same locality as the young of this species; they have grooves or striæ for their ornaments, distant $\frac{1}{4}$ of a line, one specimen showing such grooves changing into intervals between the ribs: some examples show a fracture and repair during life.

Relations.—The nearest species to this is *O. Duponti*, which has its ribs somewhat at the same distance and also irregular, but in the present they are scarcely true ribs, but rather irregular transverse folds, on which finer ornaments would never be sought. Such roughness induces me to associate the specimens (figs. 7, 8) from Ledbury with this, though much nearer to *O. Duponti* than the Scotch specimens are.

Distribution.—The typical examples are all from the Upper Silurian Beds at Esk Reservoir, in the Pentland Hills (8), whence also come the examples referred to the young of this (17). It occurs also on the west side of Kirkcudbright Bay (1), and apparently in the Upper Ludlow of Helmfoot (1); also in the Lower Ludlow of Ledbury (3). Salter records it also from Lesmahagow.

Section Angulati.

ORTHOCERAS ANGULATUM, Wahlenberg, Pl. VII. figs. 1, 3, 4, 8, 9.

1821. ORTHOCERAS ANGULATUM, Wahlenberg, 'Nova Acta Reg. Soc. Sci. Acad. Upsala,' vol. viii. p. 90.
1852. „ „ M'Coy, 'Palæozoic Fossils,' p. 313.
1854. „ „ Morris, 'Cat. of Brit. Fossils,' p. 309.
Syn. 1839. ORTHOCERAS VIRGATUM, Sowerby in Murchison's 'Silurian System,' tab. 9, fig. 11.
1839. „ CANALICULATUM, Sowerby, loc. cit., tab. 13, fig. 26, p. 632.
Query 1837. ORTHOCERAS ANGULATUM, Hisinger, 'Leth. Suec.' p. 28, pl. 10, fig. 1.

Not 1866. ORTHOCERAS ANGULATUM, Barrande, 'Syst. Sil. de Bohême,' pl. 233, p. 692.

Type.—The type is not figured by its author, though by universal consent he referred to a species identical with our British form. His description is, "The

inner construction is altogether like that of *O. imbricatum*" [i.e. the siphuncle is small and central], "but it has about twenty longitudinal ribs, and is scarcely concave between them."

General Description.—The shells of this species are so constantly found flattened, that the true shape of the section is difficult to determine; in none has it been seen circular (see Pl. VII. fig. 8); but in the least compressed, which is Sowerby's type specimen of *O. canaliculatum*, the ratio of the diameters is 22 to 25, the shorter one being in the plane of symmetry. In some examples there is a slight show of curvature, but this may be due to contortion; notably in both the types of Sowerby curvature is seen, though in *O. canaliculatum* there is less than in the other. The mean rate of increase is 1 in 9 on the septate portion, decreasing to zero towards the aperture. The body-chamber is a little longer than the diameter of its base, and attains a length of 2 inches; it is nearly cylindrical, but below the aperture there is a broad, shallow, straight depression, and then a slight expansion. The aperture is nearly direct and straight, but there is a slight convexity in its outline on the ventral side (Pl. VII. fig. 1). The ornaments show two rather distinct varieties. In the ordinary forms to which the English names were assigned, there are from 32 to 42 acute longitudinal ribs per circumference, whose intervening spaces are uniformly concave, so as to give the surface a fluted appearance; in the variety to which Wahlenberg's type would seem to have belonged, the ribs are fewer in number, from 20 to 24, and the intervening spaces are almost flat. This is of much rarer occurrence than the other. The space intervening between the ribs is marked by fine sub-imbricating transverse riblets, from 10 to 48 per line, according to the size of the shell, about 36 being in a space equal to the interval of the ribs: these have a convexity towards the aperture. The septa are a little oblique, but when seen on the dorsal or ventral side look almost direct. Their convexity is slight, not exceeding $\frac{1}{5}$ the diameter when the shell is not flattened. They are separated by rather irregular intervals, varying from $\frac{2}{7}$ to $\frac{1}{6}$ the diameter, becoming closer in proportion with age, and the last chamber is diminished to half the usual size. The siphuncle is always very near the centre; and though it passes in some cases slightly out of the central line, it never becomes in any sense lateral. Its diameter on the surface of the septum is $\frac{1}{10}$ to $\frac{1}{12}$ the diameter, but it expands between the septa into small cylindrical bulbs, whose breadth is equal to their length, and their surface smooth. The greatest length of the shell actually seen is 5 inches; but since, in one example showing this length, the greatest diameter was only $\frac{1}{2}$ inch, and others have a diameter of $1\frac{2}{3}$ inches, the total length of such an one would be 15 inches or more, since the growth diminishes with age. No really good examples of this species have anywhere been seen, nor has the apex been preserved in any in such a manner that its characters might be learned. There is a very small specimen in the Museum of the Royal College of Science, Dublin, which may represent the young of this or

possibly of *O. coralliforme*; its riblets are $\frac{1}{4}$ of a line apart, and the transverse lines, which are convex towards the aperture, are of the same size. It is from Lower Silurian rocks.

Relations.—Wahlenberg's original description of this shell being unaccompanied by a figure, authors have generally referred to Hisinger's 'Petrificata Suecana' as giving its characters. Unfortunately Hisinger describes it as having a lateral siphuncle, and draws a figure in which it stands at some distance from the centre. Whether there is actually a different species with a siphuncle in this position, with comparatively few ribs, and probably other distinctions, or whether the supposed position of the siphuncle is due to the same distortion that has produced the curvature, I cannot say; but no specimens in British collections that I have seen, of either variety, show a siphuncle that is not close to the central line. Ours, therefore, is Wahlenberg's true species, whatever Hisinger's may be. As *O. canaliculatum* was separated from *O. angulatum* on account of the supposed lateral siphuncle of the latter, it must now fall as a synonym. The simplicity of the ornaments, both large and small, distinguishes this species from others of the longitudinally ribbed group, though towards the apex they become so close as to have a resemblance to older portions of such shells as *O. filosum* and *O. originale.* The *O. princeps* of Barrande may be an aged example of one variety, and some specimens of *O. doricum* could not be distinguished from this species. The specimen he figures from Sweden as belonging to it differs in having, like *O. Bacchus*, a number of parallel intermediate riblets.

Distribution.—This is a very widely distributed species; but though I have seen one fragment from the Upper Bala of Coldwell that might be referred to this, and the young specimen in the Lower Silurian of Tipperary, well-authenticated specimens are confined to the Upper Silurian. It occurs in the Woolhope Beds at Malvern (4); in the Wenlock Shale of Ledbury (1), Dinas Bran (1), and Builth (1); and in the Denbigh Flags, Llangynyw; in the Wenlock Limestone of Dudley (15 and var. 1), Donnington (1), Nantglyn (1), and Malvern (1); in the Lower Ludlow of Dudley (2), Mocktree (5), and Ledbury (10); Llangadock (3), Llangibby (1), and Garcoed, Usk (1); in the Aymestry Limestone at Mocktree (1) and Usk (2); in the Upper Ludlow of Ludlow (5), Presteign (1), Malvern (2), Pilliard's Farm (5), Woolhope (1), Shropshire (1), Brigsteer, Kendal (3, also var. 1), and Underbarrow (1). Also from the Upper Silurian of Llanbaddock (4), in Kerry (2), Galway (2), the Pentlands (1), and Kirkcudbright (1).

It has also been recorded by Murchison from the Upper Ludlow of Abberley; by M'Coy, from the Wenlock Shale, Welchpool, and Bala Shale, Builth; by Salter, from Bala Shale, Ardwell, also from Lower Ludlow, Killington; by Phillips, from Marloes, Llandeilo, and Malvern; by Lapworth, from the Middle Silurian, Girvan; by Hughes, from the Coniston Flags; by Harkness and Nicholson, from the Grapto-

litic Mudstones of Skelgill; by Salter, in Jukes's 'S. Staffordshire Coalfields,' from Lower Ludlow, Parke's Hall, also Upper Ludlow, Coalbrookdale; by Sollas, from the Upper Llandovery, Wenlock, and Ludlow Beds of Pen-y-lan, Cardiff; by Baily, from Cloonnamera, Bleaubeg, Derrymore Glen, and Fairy Mount; and in the Catalogue of Western Scottish Fossils, from Penwhapple Glen. Being originally found in Sweden, we are not surprised that it ranges beyond there into Russia. Species under the same name are recorded from Wisconsin and Illinois.

Orthoceras coralliforme, M'Coy, Pl. VII. fig. 6.

1846. Orthoceras coralliforme, M'Coy, 'Synopsis of Silur. Foss. of Ireland,' pl. 1, fig. 3, p. 8.

Type.—Section very slightly oval, the rate of increase 1 in 6, but rather irregular. The ornaments are 30 longitudinal ribs, about one line apart, between which is an intermediate one, and sometimes two or three, still finer, on each side of this. There are also transverse riblets 4 or 5 per line. The septa are a little oblique, as indicated by broken shelly plates outstanding from an *external* cast, called lamellæ by M'Coy, about $\frac{1}{6}$ the diameter apart. No siphuncle is seen in this example. Length, $3\frac{1}{2}$ inches; diameter, $\frac{3}{4}$ inch. From Lower Silurian, Tullyconnor, Leenane. In the Museum of Royal Dublin Society.

General Description.—The section is not very far from circular, and the rate of increase is 1 in 6. No body-chamber nor aperture has been seen. The ornaments are admirably shown on an external cast from Piedmont Glen. They are about 20 in the circumference in this, but 32 in others. To the cast these give a polygonal appearance, but they are themselves acute and non-separate; between each pair is another, finer one. The surface is then beautifully cancellated, first, by sharp longitudinal lamellæ, 4 or 8 in number in each semi-interval, according as finer ones are developed or not; these are rather irregularly spaced, on the average 10 per line: secondly, by very regular transverse upward imbrications at an equal distance. The septa are indicated at from $\frac{1}{4}$ to $\frac{1}{6}$ the diameter apart; they are a little oblique and but slightly convex. The siphuncle is $\frac{4}{9}$ the diameter from the side, and is somewhat bulbous, the bulbs being cylindrical. The greatest diameter seen is $1\frac{2}{3}$ inches. It will be seen that I take the "lamellæ" of M'Coy for indications of septa; they are certainly not external ornaments, but internal projections due to the septa breaking off.

Relations.—The general character of the ornaments is similar to that of *O. Bacchus*, but there are well-marked transverse imbrications, and the ribs are more acute. When the ornaments are worn, it is difficult to separate this from *O. angulatum*, but they are quite distinct when well preserved. It may be considered as the representative of the latter in the Lower Silurian rocks.

Distribution.—In the Lower Silurian rocks, Leenane (2) and Maume (1); and in Bala Beds, Piedmont Glen, Ayrshire (1), Girvan (3), and Glengraff (1). The example from the latter locality is in the Museum of Practical Geology. M'Coy also records it from Blackwater Bridge, and Clifden, co. Galway, and Kelly from Bunowen.

ORTHOCERAS ORIGINALE, Barrande, Pl. VII. figs. 5, 5*a*, 10.

1868. ORTHOCERAS ORIGINALE, Barrande, 'Syst. Silur. de Bohême,' pl. 267, p. 206.
Syn. 1868. ORTHOCERAS STRIATO-PUNCTATUM, Barrande, loc. cit., pl. 268. (Not of Münster.)
1865. „ DULCE, Salter, 'Catalogue of Fossils in the Museum of Practical Geology.' (Not of Barrande.)

Type.—The section is circular. There is a little curvature in long shells. The average rate of increase is 1 in 6, but specimens are figured in which it varies between 2 in 15 and 2 in 7. The body-chamber is five times its basal diameter, and very little change is seen towards the aperture. The ornaments consist of regular impressed lines, without fresh ones introduced, about 60 in number. The base of these lines is smooth in typical examples; the intervening spaces are quite flat and smooth, but towards old age the right-hand side is more elevated, and the surface has extremely fine longitudinal striæ, also some transverse hollow lines declining towards the right side. Occasionally one band has similar but deeper transverse lines at an earlier age. On the inner layer of the shell there are raised lines to meet the impressed striæ, and concavities to correspond to the intermediate flat bands, so that the whole shell is formed of parts which in section look like the links of a chain. The concavities are often finely striated transversely. The septa are horizontal, and have a convexity of $\frac{1}{5}$ and a distance of $\frac{2}{5}$ the diameter. The siphuncle is nearly central; it has a diameter $\frac{1}{13}$ of the whole diameter, and is contracted at the septa. The largest specimens have a diameter of $1\frac{1}{2}$ inches, and a length of 7 inches. It is a widely distributed species, commencing in D_5, or Lower Silurian, and passing through E_2 to F_1 of the Upper Silurian.

General Description.—The peculiar feature of this shell, which it shares with the fossil referred by Barrande to Münster's *O. striato-punctatum*, but which does not agree with that author's description of his shell, is the reversed character of the inner and outer layers, the furrows of the latter coinciding in position with the raised lines of the former. This character is well seen in several British examples (see fig. 5*a*). These are usually flattened in the shale, and are otherwise imperfect; their true section is not therefore well seen, but appears to be circular. The rate of increase is very variable, according to the pressure, ranging thus between 1 in 12 and 1 in 5. The body-chamber is not certainly distinguishable; the aperture had (?) a sigmoidal outline. From 48 to 60 longitudinal sulci may be counted which have not been observed to have any punctures; the spaces are sometimes obscurely

marked transversely at half the distance of the sulci. On one side of one example, from the Wenlock Shale, Builth Bridge, there is, on the cast or inner layer, a broader depression than usual, and on each side the raised lines imbricate towards it, thus facing in opposite directions, and the two nearest are closer together (fig. 10). This may indicate something in the nature of a normal line. The septa are direct and moderately convex, and nearly half the diameter apart. The siphuncle is narrow and central. The largest seen is $3\frac{1}{2}$ inches long, and the greatest diameter seen is $1\frac{1}{4}$ inches.

Relations.—By some extraordinary oversight the name of *O. dulce* has become attached to this species in British collections, and the name has passed into catalogues. *O. dulce* has nothing to do with it, being allied to *O. Duponti.* I cannot understand how Barrande can call specimens which differ solely from this by showing punctures in the furrows (a character surely not alone sufficient for the separation), by the name *O. striato-punctatum.* Münster distinctly states that between the furrows of his species are "raised lines, with a row of elevated points," a description which would not at all apply to *O. originale.* M. Barrande states that he has compared his specimens with some examples from Münster's locality, and they agree; in which case the latter cannot be the fossils which that author describes. Our British species of *O. originale* do not show any punctures. No other species, when the two layers are seen, can be confounded with this, and they are generally in some manner indicated.

Distribution.—In the Wenlock Shale of Llanerch (1), of Builth (10), of Welchpool (1). From the Coldwell Flags (possibly this, 3). From the Lower Ludlow of Ludlow (2), of Downton (1), and of Leintwardine (3). Specimens are in the Museum of Practical Geology, the Woodwardian Museum, and those of Ludlow and Owens College, Manchester.

Orthoceras Bacchus, Barrande, Pl. IX. figs. 3, 4, 5, 6, 7.

1868. Orthoceras Bacchus, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 270, 271.

Type.—Section circular, but occasionally elliptic. In the smaller examples there is often a slight curvature. The rate of increase is 1 in 8 or 1 in 9. The body-chamber has a length $2\frac{1}{2}$ times its basal diameter. It has a broad depression below the aperture which is slightly oblique, but simple in outline. The ornaments are of four kinds: 1st, the large longitudinal narrow ribs, which start alone from the apex, and towards the aperture have a furrow on their surface as though they were tubular and worn down; 2nd, intermediate longitudinal riblets of variable size and number, and occasionally crinkled, some being more predominant, according to their earlier introduction, and all becoming bifid; 3rd, pretty regular transverse undulations, varying in intensity and dying off with age,—the longitudinal

ribs pass over them; 4th, very fine transverse striations, found only in the interval between the riblets. The septa have a convexity of $\frac{1}{3}$ the diameter; they are horizontal, and at an average distance of $\frac{1}{5}$ the diameter. The siphuncle varies in position in the same individual. It begins by being halfway between the centre and circumference, and ends by being central, but the variation is not uniform. It is slightly inflated between the septa to about $\frac{1}{6}$ the diameter; the elements lie a little obliquely. The largest specimen is about 21 inches long, and 2 inches in diameter at the base of the body-chamber. From the Upper Silurian, E 2, of Bohemia.

General Description.—This magnificent species is abundantly represented in our British Silurian rocks. Almost all specimens are compressed, and the true shape is therefore doubtful. In the least compressed body-chamber that I have seen, the section is rather quadrate, and has diameters in the ratio of 11 to 15; the actual ratio seen in most examples is not more than 1 to 2. In examples of less diameter than $7\frac{1}{2}$ lines, there is a perceptible curvature in the plane of the minor axis, and one even of large size shows a similar feature. The body-chamber has a length of twice its long and four times its short diameter in compressed examples. It shows a diminution in the rate of increase, or even a lessening diameter towards the aperture, which is surrounded, in one, by a feeble constriction. The ornaments consist, first, of primary longitudinal riblets, varying in number from 24 to 40 per whorl according to size, and partly according to individuals; secondly, there are smaller riblets of similar character which rise between the first, and gradually assume the same dimensions; and thirdly, one to three still smaller riblets lie in the concavities: all these are well separate, and, though acute when young, constantly show a groove along the top towards the large end, as though they had been hollow and worn. Another peculiarity is that the tertiary riblets may be traced growing gradually equal to the secondaries, and both to the primaries, so that on the body-chamber the distinction is almost lost (fig. 3), and in the young it is not completely developed (fig. 5). In some instructive examples of young forms of this species from the Pentland Hills, transverse undulations rising almost to ribs divide the surface, with the primaries, into squares, but these ribs fade away at a diameter of 5 lines. The same is seen in a specimen from Dudley (fig. 7). Besides these, there are very fine transverse striæ from 9 to 12 per line, that occasionally, but not constantly, cross the interspaces between the riblets. An example from the Upper Silurian of Kerry, at present referred to this species, has the secondary riblets so even in size, and the transverse ones so strongly marked, as to approach closer in its ornaments to *O. Stokesi*, Barrande. The whole of these ornaments show a tendency to die away near the aperture, and to be succeeded by transverse lines of growth only. The septa have but a moderate convexity, about $\frac{1}{5}$ the diameter, but increasing by compression to twice as much. They are very nearly direct, no greater obliquity than 10° being produced by compression. Their distance varies much with age, being

greater in youth; the mean distance is about $\frac{1}{5}$ of the compressed diameter, but the last few are crowded together. The siphuncle is seldom seen; in a small example it is $\frac{2}{5}$ the short diameter from the concave side, in a larger one it is $\frac{4}{9}$ the long diameter from the side, in others it is central, showing a variation with age as in the type. The form of its elements is seen in only one, in which it slightly expands between the septa and becomes obliquely strangulated by them (fig. 6). The largest specimen seen had a length of 13 inches and a diameter of 4 inches, but fragments indicate a still larger possible size; usual specimens are from 4 to 8 inches in length.

Relations.—This species has usually passed in collections either for *O. angulatum* or *O. filosum*, but has occasionally been indicated as a new form. From *O. angulatum* its difference is very marked; that species has no intermediate riblets of any kind. When, however, both are in the state of casts, this distinction fails; but the whole ornaments of *O. Bacchus* being more feeble, only produce at most a polygonal cast with rounded angles, instead of an acutely marked one. The present species is a much larger one. From *O. filosum* it differs in the unequal development of its riblets and the larger size of the primaries; but when in the body-chamber, the distinctions fade away: the difference of some varieties at least is very slight; and as *O. filosum* was named from a large body-chamber, the existence of that species as distinct from an adult *O. Bacchus* has to be proved, which proof will be found under the description of the species. Another form nearly allied is *O. coralliforme*, which very closely represents the young, and some examples are very difficult to distinguish. When, however, the ornaments are well preserved, they are seen to be different, the longitudinal lines are more elevated, and the transverse ones are equal in number to them. The earlier *O. coralliforme* is doubtless the progenitor of *O. Bacchus*, and in this respect is instructive as representing its early stage. Yet the modifications are sufficient to justify a separate name for the giant *Orthoceras* of the later period.

Distribution.—The earliest representative is a doubtful one from the Upper Llandovery of Myddfai, in the Museum of Practical Geology (1). It occurs certainly in the Wenlock Shale of Usk (3); in the Wenlock Limestone, Donnington; in the Lower Ludlow of Ledbury (9, mostly in the collection of Dr. Grindrod), Mocktree (1), and Dudley (1); in the Aymestry Limestone, and Upper Ludlow (3) at Ludlow; in the Upper Silurian of Kerry (4) and of the Pentland Hills (4).

ORTHOCERAS FILOSUM, Sowerby, Pl. X. figs. 8, 8*a*, 9.

1838. ORTHOCERAS FILOSUM, Sowerby in Murchison's 'Silurian System,' tab. 9, fig. 3, p. 620.
1852. „ „ M'Coy, 'Palæozoic Fossils,' p. 314.
1873. „ „ Salter, 'Cambrian and Silurian Fossils,' p. 173.

Type.—I have been unable to find this in the Collection of the Geological Society,

where most of the figured specimens of the Silurian system were deposited. We have, therefore, only the figure and description in that work. That description is, "Rather quickly tapering, longitudinally ribbed; ribs fine, numerous; septa numerous. This differs from the *O. striatum* (*O. bullatum*) in the coarseness of the lines upon the surface, which in this are sharp elevations. The position of the siphuncle is unknown. Length, $1\frac{1}{2}$ feet; greatest width, about 4 in. Ludlow escarpments." The figure shows also that the section is probably circular; the tapering at a diameter of $3\frac{1}{2}$ inches is 1 in 9. There are about 60 to 64 riblets in the semi-circumference; the septa are direct, $\frac{1}{6}$ the diameter apart at first, and later only $\frac{1}{10}$ of it.

General Description.—The specimens of this species are usually of large dimensions, and in this case their characters are well marked, but the true nature of the young is rather obscure. The section is circular, though generally compressed. The rate of increase is at first 1 in 5, but decreases through the average of 1 in 9, to be at last only 1 in 12 in the body-chamber. The latter reaches a length of 12 inches, which is four times the diameter of its base. There is a shallow constriction surrounding the aperture, which is direct and nearly straight. The ornaments are very distinct, being narrow riblets set on a flat surface (fig. 8*a*), with usually no intermediate transverse lines. These in large examples are pretty constant at 120 in the whole circumference. They are occasionally slightly irregular, and here and there a finer intermediate riblet may be seen. The septa are direct, and have only a moderate convexity; they are distant $\frac{2}{7}$ the diameter apart at the smaller end, but gradually become closer, the last few being crowded into $\frac{1}{6}$ the diameter each. The siphuncle is central (fig. 9); its elements are butt-shaped. The largest specimen critically examined is the one figured, which is 15 inches by $3\frac{1}{4}$ inches; but there are examples in the Ludlow Museum and elsewhere over 2 feet in length.

Var. *spectandum*, Pl. VII. fig. 12.—A remarkable fragment, which may at present, at least, be placed under this species, shows very similar ornaments to those of *O. spectandum* (Barrande, pl. 266), and different from the type. The primary ribs are irregular and rather more numerous, and each is furrowed along the top; between each pair of these lies a very fine parallel riblet, and the deeper spaces are transversely striated. This style of ornament when magnified resembles that in *O. Bacchus*, but on this large fragment the primaries are too small for that species. The siphuncle of this specimen is $\frac{2}{3}$ across the diameter; but this may be due to pressure. It is from the Wenlock Limestone.

Relations.—This bears very much the same relation to *O. lineatum* of the Bala Beds as *O. Bacchus* bears to *O. coralliforme*. It attains a much larger size, and in doing so puts on features which justify us in considering it a distinct species. When the primary riblets of *O. Bacchus* lose their importance, it approaches very closely to this species, which, however, retains the same ornaments from an early stage.

Our species is often confounded with *O. bullatum*, but it is immediately distinguished by its ornaments being much larger, and never appearing as impressed striæ.

Distribution.—A small specimen, whose maximum diameter is four lines, is in Dr. Grindrod's collection as from the Woolhope Shale. It abounds, however, chiefly in the Lower Ludlow of Ledbury (1), Leintwardine (5), and Dudley (1). It occurs also in the Upper Ludlow of Ludlow (3) and of Kirby Moor (1), and in the Upper Silurian of Kerry.

It is recorded by authors as from Lower Silurian rocks in Ireland, but I have little doubt that the shells intended belong to *O. lineatum.* Thus M'Coy records it from the schist of Tullyconnor, co. Galway, and Baily from Lower Silurian, Fairymount. The same explanation may probably be given, in some cases certainly, to the following references: viz., M'Coy's to the Upper Bala, Coldwell, Bala Shale, Builth, and Bala Limestone, Coniston; Hackness and Nicholson from Randy Pike; and in the Catalogue of Scottish Fossils from Drummuck. Salter, however, records the species also from the Lower Ludlow of Coalbrookdale.

ORTHOCERAS FIMBRIATUM, Sowerby, Pl. VIII. figs. 1, 2, 3.

1838. ORTHOCERAS FIMBRIATUM, Sowerby in Murchison's 'Silurian System,' pl. 13, fig. 20, p. 632.
1854. „ ANNULATUM, var. FIMBRIATUM, Salter in Murchison's 'Siluria,' pl. 26, figs. 1, 2, p. 232.
1868. „ „ Barrande, 'Syst. Silur. de Bohême,' pl. 291, fig. 7.
1873. „ „ var. FIMBRIATUM, Salter, 'Camb. and Silur. Fossils,' p. 158; also same page includes O. BRIGHTII.
Syn. 1838. ORTHOCERAS BRIGHTII, Sowerby in Murchison's 'Silurian Syst.' pl. 12, fig. 21, p. 626.
1848. „ „ (part.) Not O. MOCKTREENSE, Phillips, 'Mem. Geol. Surv.' vol. ii. pt. i. p. 353.
1852. „ „ M'Coy, 'Pal. Fossils,' p. 313.
1853. ACTINOCERAS BRIGHTII, Morris, 'Catalogue of Brit. Foss.' p. 289.
1854. ORMOCERAS BRIGHTII, Salter in 'Siluria,' pl. 27, fig. 5.

Type.—I have not been able to discover the type of this species, but the figure and description are really sufficient. The section is nearly circular, and the rate of increase is 1 in 10. The ornaments are, first, longitudinal narrow convexities, somewhat less than a line in breadth, and separated by re-entering angles; and secondly, a number of raised laminæ passing directly across the shell, about a line apart, usually about the same size, but larger ones occasionally occur at irregular intervals: these laminæ are thrown into festoons, so that the parts concave towards the aperture lie on the convexities. The septa are direct, and have a convexity of $\frac{1}{6}$ the diameter; their distance, however, is not shown, but they are said to be moderately numerous. The siphuncle is central, and $\frac{1}{7}$ of the whole diameter in size. Greatest diameter, 2 inches. From the Lower Ludlow rock.

General Description.— Specimens of this species are usually compressed, but one other besides the type shows a nearly circular section, in which case the rate of increase is 1 in 10, though generally less as measured. The ornaments consist, first, of the longitudinal convexities, which are usually, but not always, present; in some these run, as it were, in pairs, being separated by a slighter and a deeper depression alternately, in others every fourth or fifth is stronger: secondly, festoons cross these at regular distances; these are sharp raised lamellæ. The amount of curving to form festoons is variable; sometimes they are mere undulations, sometimes the concavities correspond both in size and position to the longitudinal convexities, and sometimes they are independent of them. They vary also in distance from 1 line to $\frac{1}{8}$ line, independently of the size of the shell. Towards the aperture the shell is thrown into irregular low folds, quite distinct from ornamental ribs, distant about $\frac{1}{14}$ the diameter (fig. 1); a thickening of the shell takes place here in one, and the aperture is slightly oblique. Over the ornaments are preserved in some instances longitudinal bands of colour (fig. 3), the darker bands corresponding to the convexities and the lighter ones to the re-entering angles, and they thus vary in breadth with these. The septa are direct, or slightly undulating, and have a convexity of $\frac{1}{4}$ the diameter; they are distant $\frac{1}{5}$ the diameter. The siphuncle is central, and in one example has a diameter $\frac{1}{5}$ the whole, so that its elements should be as broad as they are long; but they have not been certainly seen in connection with the exterior shell. There can, however, be little doubt that it is to this species that the siphuncles commonly known as *Orthoceras Brightii* should be referred (fig. 2). It is true that Phillips (loc. cit.) states that a large series in the collection of Mr. Lewis proves that these siphuncles belong to *O. mocktreense*, but that species has spherical bulbs. It has long been suspected, and ultimately stated by Salter (loc. cit.), that this is the siphuncle of *O. fimbriatum*. It could not belong to *O. annulatum*, because the outline of the shell in the matrix is invariably straight, nor is it likely to belong to a smooth or slightly ornamented species, or its exterior would have been seen before now; but the upright lamellæ of *O. fimbriatum* are just the suitable holdfasts to keep it inextricably bound to the rock. These siphuncles agree in size and distance, and the shell agrees in shape with *O. fimbriatum*. We thus learn that the siphuncle of this shell has cylindrical elements a little less broad than long. They are affected as little as possible by the septa, so that it is puzzling to know what could have induced anyone to call them *Actinoceras* or *Ormoceras*. A section, however, shows that there was a little obstructing deposit at the junction, which narrows the tube internally, and whose outside is doubtless Sowerby's "plicated membranous bag." This species attains a greater size than *O. annulatum*, the longest being 20 inches, and the greatest diameter under compression $3\frac{1}{2}$ inches. The specimens are usually large, but all the characters are observed without change down to a diameter of $\frac{1}{2}$ inch.

Relations.—This species has been by many, though not by all, considered to be a variety of *O. annulatum*, and it is undoubtedly closely allied to it. It seems to me, however, to be worthy of a distinct name, for the following reasons:—The least ribbed varieties of *O. annulatum* always give some indication of the ribs, however feeble, but in those referred to *O. fimbriatum* no sign of such transverse risings of any kind is seen over any part of the shell, even when of small size. In the former also the longitudinal elevations are quite exceptional, in the latter they are the rule. Sowerby states as one of the differences that the festoons in *O. annulatum* end on the convexities, and in *O. fimbriatum* on the concavities. This is not universally the case; they lie irregularly; but in the latter species the festoons are much more subordinate to the longitudinal ornaments. In septal and siphuncular characters they are very much alike, but in the present species the elements of the siphuncle are shorter, and, if we are right in referring *O. Brightii* to it, the deposits at the junction with the septa are a phenomenon not found in *O. annulatum*.

Distribution.—In the Wenlock Limestone of Dudley (4), Malvern (1 and 9 siphuncles), Ledbury (1), Usk (1), and Eastnor (1 siphuncle); in the Lower Ludlow of Ledbury (5), Aston (1), and Ludlow (1 siphuncle); and in the Aymestry Limestone of Woolhope (1 siphuncle).

Section Lineati.

ORTHOCERAS ARGUS, Barrande, Pl. VI. figs. 13, 14.

1868. ORTHOCERAS ARGUS, Barrande, 'Syst. Sil. de Bohême,' pl. 325, p. 476.

Type.—The section is generally circular, but is occasionally somewhat elliptic. The rate of increase is 1 in 7. The body-chamber has a length equal to $2\frac{1}{2}$ times the basal diameter. The aperture is direct and simple, but below it is a slight depression of the shell. The ornaments are sharp, direct riblets, about 40 per line. The septa are direct, and distant $\frac{2}{5}$ the diameter; their convexity is less than half the same line. The siphuncle is always near, but sometimes not quite at, the centre; its elements are cylindrical, and its size moderate. The greatest length is 5 inches, and the greatest diameter $\frac{3}{4}$ inch. From the stage F of the Upper Silurian.

General Description.—The British examples referred to this species agree, so far as they go, very fairly with the above description. The section is nearly circular, the ratio not being greater than 16 to 15. The rate of increase is between 1 in 7 and 1 in 8. The ornaments are direct sharp riblets of considerable regularity, and from 32 to 36 per line, perfectly observable although so small. The characters of the body-chamber and aperture have not been observed. The septa are nearly direct, and distant $\frac{1}{3}$ the diameter; their convexity is $\frac{2}{7}$ the same line. The siphuncle

is $\frac{3}{6}\frac{1}{4}$ across the longer diameter, and is small in size on the septal surface. The greatest length seen is $3\frac{3}{4}$ inches, and the greatest diameter $\frac{2}{3}$ inch.

Relations.—The peculiar feature of this species is the presence of excessively fine, and yet perfectly preserved, acute riblets. It is curious that both the Bohemian and our own fossils are pseudomorphs in calcite, and it may be from this cause that such riblets are preserved. Barrande separates from this species, under the name of *O. capillosum*, some larger shells which have longer body-chambers, a triflingly less rate of increase, and the riblets only about 20 per line. This latter is very widely distributed in time, ranging from stage E to H; and if *O. argus* were to be considered a local variety of it, with which the British species more nearly agreed, it would be more satisfactory, as ours also has a wide range of time. It differs from the other British species with fine riblets in their excessive number, and from most of them in their directness.

Distribution.—The four examples referred to this species, and which I am unable to separate by any positive character, come from widely different horizons. One is from the Middle Bala of Holbeck Gill, and this does not show its siphuncle well, as there is an appearance, which I think delusive, as if it were lateral. The second is from the Wenlock Shale, Kingswood Fordon; the third is from the Lower Ludlow of Ludlow; and a fourth in the Upper Silurian, bed H, of the Pentland Hills, may be the same.

ORTHOCERAS EXPANSUM, Blake, Pl. VI. fig. 15.

Query 1846. ORTHOCERAS LINEARE, M'Coy, 'Sil. Foss. of Ireland,' p. 9. (Not of Münster.)

Type.—The shell is nearly flattened; the rate of increase is greater than 1 in 6. The ornaments are fine undulating riblets, not very elevated; these are not parallel to the septa, and rise more on one side than on the other, being somewhat oblique; at a diameter of 7 lines they are 12 per line. The septa are nearly direct and very remote, viz. $\frac{2}{3}$ the diameter; the siphuncle is not seen. The length is 2 inches, and the greatest diameter 7 lines. From the Bala Series of Desertcreat. In the Museum of Practical Geology.

General Description.—Another example referred to this shows the section to be elliptic in the ratio of 13 to 11; the rate of increase is the same as in the type. The ornaments, though sharp, have a tendency to imbricate upwards. In the other examples they are fewer than in the type, namely, 5 to 10 per line, but some variation must be admitted in these ornamented species. The septa are nearly direct, as in the type, and so are not parallel to the ornaments; they are distant in another example $\frac{1}{2}$ the diameter, and the sutures are a little undulating. No siphuncle has been seen. The greatest length seen is 3 inches, and greatest diameter 10 lines. One example shows the mending of the shell during life.

Relations.—This species is distinguished from the rest of the group to which it belongs by its rapid rate of increase and widely-separated direct septa. It is a stout form. It would, however, nearly correspond to *O. centrale* (Hisinger) if the riblets were not undulating.

Distribution.—In the Bala Beds of Desertcreat (1), Barnne, co. Tipperary (1), Dooree (a more doubtful example) and Kildare (1).

Orthoceras elongatocinctum, Portlock, Pl. XIII. figs. 7, 8, 8*a*.

1843. Orthoceras elongatocinctum, Portlock, 'Geol. Report,' pl. 27, fig. 2 *a*, *b*, p. 372.
1860. „ „ Baily, Explanation of Sheet 145, 'Geol. Surv. of Irel.' pl. 11, fig. 3.
1869. „ „ Baily, 'Characteristic Brit. Fossils,' pl. xii. fig. 10.
Syn. 1843. Orthoceras subflexuosum, Portlock, loc. cit., pl. 28, fig. 3, p. 318. (Not of Münster.)
1843. „ tenuicinctum, Portlock, loc. cit., p. 371.
1852. „ „ M'Coy, 'Pal. Foss.' p. 317.
1854. „ „ Salter in Murchison's 'Siluria,' Foss. gr. 42, fig. 3.
Query 1843. Orthoceras regulare, Portlock, loc. cit., pl. 27, fig. 5.

Type.—Two specimens are figured by Portlock as types, which differ in some respects from one another, but which nevertheless cannot, with present materials, be satisfactorily separated. The section in both is compressed; the rate of increase in the one (fig. *a*) is 1 in 14. The body-chamber cannot well be distinguished from the septal portion. The ornaments in fig. *a* are acute undulating riblets, with very little obliquity, and distant 9 per line at a diameter of 4 lines; they show a slight tendency to group in series. In fig. *b* the ornaments are more undulating and oblique in appearance, and distinctly cross the line of the septa, and are distant 10 per line. The septa slope in an opposite direction to the ornaments, and are $\frac{2}{7}$ to $\frac{2}{5}$ the diameter apart. No siphuncle is seen. The larger of these has a length of $3\frac{1}{3}$ inches, and a diameter of $\frac{3}{8}$ inch. From the Bala Series of Tyrone. In the Museum of Practical Geology.

General Description.—One example referable to this species has an elliptical section, with diameters in the ratio of 10 to 9. In another they are as 7 to 6. The rate of increase is always small, not greater than 1 in 10. The ornaments would appear to vary according to the direction in which they are seen; though always undulating, their obliquity is more marked when they are seen to cross the septa, by being viewed on the side; they are sharp and separate. Better specimens might show that there are two species, as there appear to be amongst corresponding forms of the Upper Silurian, viz. those with more direct and those with oblique riblets crossing the septa, but no satisfactory distinction can now be drawn. The riblets are from 10 to 12 per line, or even 18 in very small specimens. The septa are

slightly oblique, about 5° in a direction contrary to the ornaments, which often pass across from one septum to the next. Their distance, as seen in the specimen figured by Portlock, as *O. subflexuosum*, is $\frac{1}{4}$ the diameter; their convexity is $\frac{1}{3}$ of that line. If a small septal surface is rightly associated with this species, the siphuncle is $\frac{3}{7}$ the long diameter from the side. The diameter is usually less than $\frac{1}{2}$ an inch, but the length is considerable, so that the whole shell is a small and delicate one.

Relations.—As will be seen from the synonymy, these finely-marked *Orthocerata* from the Lower Silurian rocks have been separated into several species, but their limits have never been well defined. The smaller number of riblets has been made use of as a character for *O. tenuicinctum*, but there are graduations in this respect so close, as to make it impossible to draw a satisfactory line. A more hopeful means of separation is by the amount of the undulations of the ornaments, but I have not found any in which they do not undulate at all. The riblets are far less numerous than in *O. argus*. A very similar shell is *O. expansum*, when the details are considered, but it is altogether a robuster form, and the septa are more distant and the rate of increase greater. From *O. undulocinctum*, on the contrary, it differs by the greater number of its riblets, and from *O. recticinctum* by their undulation.

Distribution.—The greater majority of examples are from the Bala Beds of Desertcreat (12), but it occurs also at Kildare (3) and Coldwell (2).

It is recorded by Baily from thirty-seven localities in Tipperary from the Lower Silurian (see Explanation of Sheets 133, 135, 145). M'Coy records it from Lower Silurian, Galway; and Lapworth from the Middle Silurian, Gala.

A minute specimen (Pl. XIII. fig. 10), in the Woodwardian Museum, from the Bala Limestone, Dent, about 1 inch long and 2 lines in diameter, shows a beautifully cancellated surface. The transverse riblets are 15 per line, and the longitudinal about the same: the latter look as if they were dying off; and as many species have longitudinal lines in youth which are subsequently lost, it is very probable that the specimen may represent only the young of the present species, with which it agrees in general character. It stands, however, in the Museum Catalogue as "*O. conularia.*"

Orthoceras undulocinctum, Blake, Pl. XIII. fig. 9.

Type.—The shell is compressed, so that the axes are in the ratio of 3 to 2. The rate of increase is about 1 in 6. The ornaments are transverse sharp riblets, which are oblique in the contrary direction to the septa, and cut across two chambers in crossing from side to side. These are about 7 per line. The septa are only seen to undulate on the surface exposed, but this is probably due to their obliquity; they are distant $\frac{1}{5}$ the diameter. The siphuncle is not seen. The length is $1\frac{2}{3}$ inches, and the greatest diameter $\frac{3}{4}$ inch. From the Upper Ludlow, Ledbury. In the Museum of Practical Geology.

General Description.—The specimens of this species usually occur flattened in the stone, so that their true section is unknown. The rate of increase is usually less than the type down to 1 in 10 only, as far as seen. The ornaments are often well marked and sharp, but characteristically undulate so as to clearly cross the septa. They vary in number from 6 to 11 per line. The septa are always close, sometimes only $\frac{1}{7}$ the diameter apart. No siphuncular characters have been satisfactorily determined. The greatest diameter seen is 1 inch. Like many of these shells, examples occur which have been mended during life.

Relations.—The large size, more rapid rate of increase, and the closeness of the septa separate this from *O. elongatocinctum*, whose riblets, moreover, are usually more numerous. From *O. expansum*, the closeness of the septa and the less numerous riblets also distinguish it; and the obliquity of the latter separates it from the commoner *O. recticinctum.*

Distribution.—Examples occur in the Upper Ludlow of Ludlow (2), Aymestry (3), Malvern (1), and Kendal; also in the Aymestry Limestone (2), Ludlow, and in the Upper Silurian of the Pentlands (1).

ORTHOCERAS RECTICINCTUM, Blake, Pl. XI. fig. 4.

Query 1870. ORTHOCERAS CENTRALE, Barrande, 'Syst. Sil. de Bohême,' pl. 438. (Not of Hisinger.)

Type.—The shell is now flattened, and the present rate of increase is 1 in 12. It is impossible to tell where the body-chamber commences, but it is probably of considerable length. The ornaments are sharp transverse riblets, which are on the whole direct, though they are not rigid, but liable to slight undulations, and tending to group themselves: there are about 7 per line. The septa are direct and parallel to the ornaments, and distant about $\frac{1}{5}$ the diameter. The siphuncle is moderate and central. Length, $6\frac{1}{2}$ inches; greatest diameter, 10 lines. From the Upper Ludlow, Ludlow. In the Ludlow Museum.

General Description.—Very little can be added by other specimens to the characters of the type. The apparent rate of increase in shorter fragments is often 1 in 8. The ornaments are always characteristic in their sharpness and general directness; they vary in number from 7 to 10 per line. The septa are not often seen, but are always direct and less than $\frac{1}{4}$ the diameter apart. The type is the largest known.

Relations.—This is really a very distinct species, and can only be confounded with others when the obliquity of their ornaments is not seen or the slight undulations of those of the present exaggerated. Examples have usually been confounded either with *O. subundulatum*, from which the character of the ornaments at once distinguishes it, or with *O. elongatocinctum*, which is a much nearer ally,

if not an ancestor, but which has more numerous and finer riblets, often more undulating and the septa more remote.

Distribution.—In the Lower Llandovery, Helmsknot (1); in the Wenlock Shale of Oernant (1), Coldwell (1), Dinas Bran (1), Dudley (1), Barrington (1), and Llandewi (1); in the Wenlock Limestone of Usk (1); in the Coniston Flags (5); in the Lower Ludlow of Ledbury (3); in the Upper Ludlow of Woolhope (1), Ludlow (7), Ledbury (2), Malvern (3), Presteign (2), Mocktree (1), Builth (1), and Benson Knot (1); and other Upper Silurian localities.

NOTE.—There are two specimens in the Woodwardian Museum from the Lower Bala of Llandeilo and Builth respectively (one of them named *O. fluctuatum* by Salter), which have so strong a resemblance to this that, had they occurred in Upper Silurian rocks, they would have been unhesitatingly referred to it, but there are not sufficient characters preserved to prove their identity.

ORTHOCERAS PENDENS, Blake, Pl. XI. figs. 2, 2*a*, and 5.

Type.—Two examples, which undoubtedly belong to the same species, but give supplementary information, may be combined as types. The section is elliptic, the ratio of the diameters being as 5 to 4. The rate of increase is from 1 in 6 to 1 in 7. The body-chamber has a length equal to three times the longer diameter of its base, and the aperture is simple without any change of growth. The ornaments are sharp riblets parallel to the septa, and distant about 6 per line at a diameter of 5 lines (fig. 5). The septa are from 8°–10° oblique on the shorter diameter, and are distant about $\frac{2}{7}$ the same line; their convexity is equal to their distance apart, and is at a maximum nearer the lower side. The siphuncle, which is moderate in size and central, is thus not on the summit of the convexity, but on the longer slope in the direction of the short diameter (fig. 2*a*). The length of the example, which is all body-chamber, is $2\frac{2}{3}$ inches, and its greatest diameter is $1\frac{1}{4}$ inches. From the Bala Series, Glencotho Quarry, Broughton. In the Museum of the Geological Survey of Scotland.

General Description.—Only one other example from the same locality has been seen, which confirms generally, but adds nothing to, the types.

Relations.—Belonging by its ornaments to the group of *O. tenuicinctum*, it differs from them all by the obliquity of the septa and of the ornaments being in the direction of the shorter rather than the longer diameter.

Distribution.—In the Bala Series, Broughton (3).

ORTHOCERAS GRINDRODI, Blake, Pl. IX. fig. 9.

Type.—The section is slightly elliptical, the diameters being in the ratio of 13 to 12. The rate of increase is 1 in 13. The ornaments consist of vertical sharp sepa-

rate riblets, or crinkly lamellæ, continuing in a uniform curve which is direct on one of the broader and both of the narrower sides, but undulates backwards on the other broad side. These are at varying distances, being 7 per line at a larger diameter, and only 5 at a smaller. The body-chamber contracts a little towards the aperture, which is simple and transverse. The septa are direct and distant $\frac{2}{7}$ the diameter; their convexity is moderate. The siphuncle is not properly seen. The greatest length is 12 inches, and the greatest diameter 2 inches. From the Lower Ludlow of Ledbury, in the collection of Dr. Grindrod, after whom it is named.

General Description.—Other examples in the same collection confirm the general tapering and ornaments. One of these, a polished section, gives the details of the septa. They are direct and distant $\frac{1}{4}$ the rather flattened diameter, and their convexity is not more than $\frac{1}{8}$ the same. The siphuncle is central in the diameter exposed, but by pressure it is displaced in other diameters. It has a diameter between the septa of $\frac{1}{6}$ the whole, its elements being thus cylindrical. There is a little organic deposit at the necks, and it is impossible to distinguish the substance of the covering of the siphuncle from that of the septa. In the sides of the earlier chambers there are very instructive instances of organic deposit.

Relations.—This magnificent form is obviously a near ally of *O. fimbriatum*. It is not, however, fluted or coloured longitudinally, and the transverse lines are in much finer festoons, so as to be merely minutely undulating. They are, however, of the same type as in *O. fimbriatum*, and justify the separation of the latter from *O. annulatum*.

Distribution.—In the Lower Ludlow of Ledbury (3), and possibly in the Upper Ludlow of Ludlow (1).

ORTHOCERAS POMEROENSE, Portlock, Pl. XI. fig. 1.

1843. ORTHOCERAS POMEROENSE, Portlock, 'Geol. Report,' pl. 26, fig. 4.
Syn. 1843. ORTHOCERAS IRREGULARE, Portlock, loc. cit., p. 375. (Not of Münster.)
1843. „ COMPLANATOSEPTUM, Portlock, loc. cit., pl. 28 B, fig. 1, p. 374.
1843. „ TUMIDUM, Portlock, loc. cit., pl. 28, figs. 5, 6, p. 373.
Query 1843. ORTHOCERAS REGULARE, Portlock, loc. cit., p. 376, pl. 27, fig. 4*b*. (Not of Münster.)

Type.—The specimen to which Portlock's name, here adopted, was assigned, consists merely of fragments of shell surface, showing sharp transverse irregular lines of growth corresponding to a tolerably large species. It is, however, the least objectionable of the names quoted above, which together are thought to represent a fairly well characterised species. The type is from the Bala Series of Desertcreat, and is in the Museum of Practical Geology.

General Description.—The section is always seen elliptic, and perhaps was naturally so, as it retains that shape when the pressure has been perpendicular to the axis. The rate of increase is with difficulty ascertainable, but is probably between

1 in 14 and 1 in 17, allowing for the flattening. The body-chamber has in one example a length of $7\frac{1}{2}$ inches, which is about twice the length of the basal diameter, if that were unaltered. Perhaps the shell was thickened near the aperture, which was simple and direct in outline. The surface had irregular transverse lines of growth, which were sharp or not according to preservation; they have a peculiar irregularity and straightness, and every third or fourth is stronger, but without any order. The septa are direct, and have in their normal state a convexity of $\frac{1}{3}$ the diameter, and are distant about $\frac{1}{6}$ the diameter. The siphuncle is only slightly eccentric on the short diameter, is $\frac{4}{9}$ across, and has a diameter $\frac{1}{8}$ of the whole. The greatest diameter in a flattened shell is about 4 inches, with a length of $7\frac{1}{2}$ inches. This description is taken from several examples, whose ornaments and association in the same bed appear to indicate them to be the same species, but there are no specimens which show all the characters at once.

Relations.—The specimens called *O. irregulare* by Portlock have the surface ornaments more than usually well preserved, but they differ in no essential particular from those of the type, and there are no other distinguishing characters. His type specimen of *O. complanatoseptum* owes its peculiarity merely to the pressure having been exerted on the septal surface, which has partly broken down and become flat; the eccentric siphuncle is confirmed by three other examples, and the ornaments are those of the type. The specimens figured as *O. tumidum* likewise show similar ornaments; but the last chamber has resisted compression, and has been distorted so as to face the side. Some of the specimens, all of obscure character, referred to *O. regulare*, agree fairly with our present species.

This species is very closely related to *O. politum*, and it is very probable that some of the specimens referred to it should belong to the latter; nevertheless there are others which from their deeply-marked lines and close septa are clearly distinct from it. It is also very close to *O. mocktreense* and *O. fretum*, from the Upper Silurian, from the latter of which it differs by having its siphuncle on the smaller and not on the larger diameter; from the former it is distinguished by details of ornaments, and by not having a bulbous siphuncle.

Distribution.—All the specimens examined are from the Bala Series, Desertcreat (14). M'Coy records it (as *O. tumidum*) from the same beds at Tornaskea; and Phillips from the Llandeilo district.

Orthoceras araneosum, Barrande, Pl. XVII. figs. 2, 2*a*.

1868. Orthoceras araneosum, Barrande, 'Syst. Silur. de Bohême,' pl. 337–40, p. 283.
Query 1872. Endoceras proteiforme, Nicholson, 'Geol. Mag.' vol. ix. p. 102.

Type.—Barrande gives a large number of figures of this species, and describes it as a very variable one. The section is most often circular, but in some the ratio of

the axes is 9 to 8. Many show some curvature. The rate of increase is 1 in 8, in the younger shells 1 in 6. The ornaments consist of a network of longitudinal and transverse raised lines, of variable number, but always very close; sometimes one set and sometimes the other predominate. There are often also transverse folds of growth, and occasionally irregular folds in a longitudinal direction. The septa are direct, at variable distances, the average being $\frac{1}{5}$ the diameter; their convexity is the same fraction. The siphuncle is sub-central. The greatest diameter figured is $2\frac{1}{4}$ inches. From the stage E of the Upper Silurian.

General Description.—Two British examples of large size show a similar reticulation; they are both compressed; the smallest ratio of the diameters being 4 to 3. Their mean rate of increase is 1 in 7. The longitudinal lines are from 4 to 5 per line, and the transverse ones are rather less conspicuous, but about equal in number. The septa in the larger would appear to be more remote than in the type, being $\frac{2}{5}$ of the mean, though less than $\frac{1}{4}$ the actual longer diameter; their convexity is equal to their distance, and the siphuncle is central and of moderate size, if it be really seen. The greatest diameter of the compressed shell is $3\frac{1}{2}$ inches.

Relations.—This at first sight has the general aspect of such species as *O. filosum* or *O. bullatum*, but neither of those shows such a network of ornaments. I have not been able to examine the fossil which Professor Nicholson refers to *Endoceras proteiforme*, which appears to have been mislaid, but the description of it agrees essentially with our present species as far as the ornaments, which alone are preserved, are concerned. It is scarcely justifiable to assume the presence of a subgenus founded on peculiarities of the siphuncle, because of the existence of ornaments which may be matched in an ordinary *Orthoceras*.

Distribution.—The two specimens examined are from the Wenlock Shale of Buildwas, and from the Upper Ludlow of Kendal. Prof. Nicholson's example is from the Graptolitic Mudstones of Skelgill.

ORTHOCERAS SEMIPARTITUM, Sowerby, Pl. XIV. figs. 9, 10, 11, 11*a*, 12.

1838. ORTHOCERAS SEMIPARTITUM, Sowerby in Murchison's 'Silurian System,' pl. 3, fig. 9*a*, p. 904.
1852. " " M'Coy, 'Pal. Foss.' p. 316.
1873. TRETOCERAS SEMIPARTITUM, Salter, 'Camb. and Sil. Foss.' p. 192.
Syn. 1848. ORTHOCERAS TEXTILE, Phillips, 'Mem. Geol. Surv.' vol. ii. pt. i. pl. 13, figs. 5, 6.

Type.—The section is nearly if not quite circular; the rate of increase is 1 in 6. The whole is a septate cast. The septa are direct, their convexity very moderate, and their distance $\frac{1}{5}$ the mean diameter. The siphuncle is nearly central, but if anything on the smaller diameter, nearer the side to which it is connected. The hollow left in the cast, where the shell originally was, indicates that the septal plates

were thicker towards one side than on the other, and where they were thicker there was also a plate which connected the siphuncle with the side of the shell throughout the whole chamber. The greatest diameter is $\frac{1}{4}$ inch, and the length is $\frac{1}{2}$ inch. From the Tilestones of Horeb Chapel. In the Museum of the Geological Society.

General Description.—The section in some examples appears to be elliptical, with the axes in the ratio of 3 to 2; but as the shorter diameter corresponds to the exposed side, this is probably due to weathering. The rate of increase is uniformly 1 in 6. Nothing but septate fragments have been seen. As to the surface ornaments, Phillips's type specimens of *O. textile*, while they show the septal characters of the present species, have not been observed by me to show any ornaments: but doubtless the fragment figured by Phillips belongs to the same as the rest, in which case the surface must have been marked by lines crossing each other so as to form a network (fig. 12). The septa are direct and their convexity slight. In very minute shells they are distant as much as $\frac{1}{2}$ the diameter (fig. 11), but they must rapidly grow closer, as all ordinary examples have them from $\frac{1}{4}$ to $\frac{1}{5}$ of that line apart. The siphuncle is near the centre, but lies rather nearer the side which has the plate (fig. 10). It is stated to be lateral by Phillips in his *O. textile,* though one figure gives it correctly near the centre. The feature which induced the idea of its being lateral is as follows:—On one side of each septal chamber is a longitudinal elevation in the cast, which becomes more prominent towards the base, and in fact forms one of the ordinary discontinuous normal lines, and is unconnected with the siphuncle, though often looking like one. Towards this side the septa thicken and leave in the cast a wider gap between the hollow parts of the chambers (fig. 9), which are now filled with matrix. From the same side starts a plate, or probably two, which run together to the siphuncle, though diverging towards the surface, just as though the shell-secreting mantle instead of being pierced by the siphuncle had been forced to go round it, and at the same time to stay as close as possible to the circumference. The plate is thus deposited towards the base only of each chamber, by the apposed sides of the mantle; for though the cast of the concave part of the chamber shows the marks of this deposit, that of the convex part shows none. The phenomenon is therefore one confined to each chamber, and is not the same as the backward prolongation of the body-chamber in *Tretoceras.* It may, however, be due to the organic deposit.

Relations.—There cannot be the slightest doubt that the species described by Phillips as *O. textile* is the same as Sowerby's originally described cast; they differ in no single respect, though mutually illustrative. It may be mentioned that the supposed lateral siphuncle of *O. Steinhaueri*, from the Carboniferous rocks, is really the same surface depression or discontinuous normal line, and similar appearances are amply illustrated by Barrande. If the specimens seen are adult, this must be a cancellated species, but it may be only cancellated in youth, and the adult form be less peculiarly marked, which would account for the ornaments being so seldom

seen. The plate in the chambers may perhaps be compared with the flat band seen on the septa of *O. imbricatum.*

Distribution.—In the Tilestones of Horeb Chapel (4); in the Upper Ludlow of Freshwater East (5) and of Usk (1).

It is also recorded by M'Coy from Lower Silurian, Tonlegee, but this is perhaps a doubtful identification; also by Strickland, from the Ludlow Bone Bed near Lyne Down.

ORTHOCERAS LINEATUM, Hisinger, Pl. VII. figs. 2, 11.

1837. ORTHOCERAS LINEATUM, Hisinger, 'Petrefacta Suecana,' tab. 9, fig. 9, p. 29.
1843. „ „ Portlock, 'Geol. Report,' p. 370.
1846. „ „ M'Coy, 'Silurian Fossils of Ireland,' p. 9.
Syn. 1820. ORTHOCERAS STRIATUM, Marcklin, Hisinger, 'Anteneckner V.' tab. v. fig. 1. (Not of Sowerby.)
1843. „ SUBCOSTATUM, Portlock, 'Geol. Report,' pl. 26, fig. 6, p. 371.
1852. „ STRIATOPUNCTATUM, M'Coy, 'Pal. Fossils,' p. 9. (Not of Münster.)
1852. „ LAQUEATUM, M'Coy, loc. cit., p. 315.
1873. „ „ Salter, 'Cambrian and Silurian Fossils,' p. 98. (Not of Hall.)

Type.—Hisinger states only that his species has a cylindrico-conic shell, longitudinally very finely striated, and the siphuncle central. His figure, however, shows that the section is circular, and the tapering 1 in 8. The ornaments are sharp lines about 60 or less in the circumference. The septa are direct, and have a convexity of $\frac{3}{10}$ their diameter; the siphuncle is moderate in size. From the Lower Silurian of Sweden.

General Description.—This species has often been quoted from British strata, but from the want of further details about the Swedish form, and the fragmentary state of our own, the reference may be somewhat doubtful. Certainly there are examples which differ in no important particular from the above description of the type. The section may be circular, but is always flattened. The rate of increase is 1 in 7 to 1 in 10, decreasing to almost zero in the body-chamber, which has a length three times its basal diameter. The aperture is bounded by a curve which has a forward bend on the sides. The ornaments are sharp, raised, separate riblets on a flat surface, which are angular on the shell and more rounded on the cast. In some cases there appear to have been very fine longitudinal lines parallel to these. The riblets vary in number from 36 to 44 per circumference, though in one example, possibly the fragment figured by Portlock as *O. subcostatum*, only 10 are seen on the surface exposed. As this is not proved to represent the half circumference, we can scarcely consider such to belong to a separate species. The septa are direct, their convexity is considerable when flattened, and they are distant $\frac{2}{5}$, or less, of the diameter. The

siphuncle is central. The greatest length seen is $2\frac{1}{2}$ inches; the greatest diameter, 5 lines.

Relations.—When no distinctive characters are derivable from the septa and siphuncle, the only marks by which to separate these longitudinally ribbed species are the number of the riblets and the rate of increase. The latter, from compression, is seldom a safe guide, and to judge of the former we must at least have a semi-circumference preserved. Fragments are therefore difficult to localise, but in the Bala rocks there are certainly some whose riblets are better marked and more remote than in others: to these the name of *O. lineatum* may be reserved. These are comparatively delicate shells, admitting of no real comparison with such giants as *O. filosum*, although that may be similarly ornamented. No specimens have been seen which justify the introduction of such names as *O. laqueatum* or *O. striato-punctatum*, which are founded on details of ornament not to be demonstrated on British fossils.

Distribution.—Fragments which may be referred to this species occur in the Middle Bala Beds of Holbeck (1); in the Upper Bala of Coldwell (1); in the Bala Beds of Desertcreat (6), and in the Lower Silurian of county Tipperary (3); also the Coniston Flags at Hawkshead (1) and Coniston (1).

Fossils under this name, or its synonyms, have been described by M'Coy as common in the grey calcareous slates at Glengraff, Galway; but those I have seen from here show no satisfactory characters. Mr. Baily records it also from Lower Silurian Beds at Ballycar, Ballenbrook, and Killoskehan, co. Tipperary. It ranges also, according to authors, through Sweden, Norway, and Russia, so that, though absent from the Welsh area, as far as at present known, some such form was a widely distributed one during the Bala period.

ORTHOCERAS LINEATUM, *var.* TENUISTRIATUM, Portlock, Pl. VII. figs. 7, 13.

1843.	ORTHOCERAS TENUISTRIATUM,	Portlock, 'Geol. Report,' pl. 28, fig. 1, p. 370. (Not of Münster.)	
1852.	,, ,,	M'Coy, 'British Palæozoic Fossils,' p. 317.	
1854.	,, ,,	Morris, 'Catalogue of Brit. Fossils,' p. 312.	
1870.	,, LINEATUM,	Barrande, 'Syst. Silur. de Bohême,' pl. 438, p. 704.	

General Description and Relations.—A few specimens associated with the above species, with others having a larger range, appear to differ from it only in the greater number of the riblets. To these the name given by Münster to a Devonian fossil has been usually applied. This, however, has been described by him as having a thick shell, these being thin, and it is scarcely likely that our specimens have a closer relationship to those of so much later date than to their associates in the same beds; as a specific name, *tenuistriatum* is, therefore, inapplicable, but may be used

as a varietal one until other associated characters justify a separation. In the type the number of riblets in a space equal to the diameter would be 14. In those included in the present variety, the number ranges from 24 to 48 in the same distance. The examples from Upper Silurian rocks appear to be of larger size than the others, and one (fig. 13) approaches *O. originale* in appearance, except for the more numerous riblets, and is associated with it.

Distribution.—In the Bala Beds of Desertcreat (?—Portlock's type not seen), and of Tipperary (1) and Mullock (2); in the Lower Llandovery of Haverfordwest (1) and the Upper Llandovery of Marshbrook; in the Wenlock Shale of Builth (1).

It is also recorded by Harkness and Nicholson from Randy Pike, and a similar form occurs at Kirkcudbright.

ORTHOCERAS BULLATUM, Sowerby, Pl. XII. figs. 4, 5.

1838. ORTHOCERAS BULLATUM, Sowerby in Murchison's 'Silurian Syst.' pl. 5, fig. 29, p. 612.
1852. ,, ,, M'Coy, 'Pal. Foss.' p. 313.
1867. ,, ,, Dixon, 'Woolhope Nat. F. Club, Fossil Sketches,' No. 1, fig. 1, p. 136.
Syn. 1838. ORTHOCERAS STRIATUM, Sowerby, in explanation of figures as above. (Not O. STRIATUM, M.C., t. 58.)
1847. ,, SUBSTRIATUM, D'Orbigny, 'Prodrome,' p. 54.

Type.—The specimen is flattened so that the section is unknown, and the rate of increase becomes 1 in 9. Only the commencement of the body-chamber is seen. The ornaments are regular longitudinal impressed striæ with flat interspaces, distant six per line at a diameter of 19 lines. The sutures are now oblique 3°, and distant $\frac{1}{8}$ the compressed diameter. The siphuncle throughout the space in which it is seen has 2 lines' diameter, though the shell has increased its size. The form of its elements changes with growth; in the earliest part they are bulbous between the septa, and later they are flatter or cylindrical, thus accounting for the want of increase in the size. The total length is $8\frac{1}{4}$ inches, and the greatest diameter is 19 lines. From the Upper Ludlow of Ludlow. In the Museum of the Geological Society.

General Description.—In uncompressed specimens the section is circular. There is in some a slight curvature of radius 15 in. The rate of increase at first is 1 in 6, but in the body-chamber it decreases to almost zero. The length of the body-chamber is not more than twice its basal diameter, and has a very slight contraction below the aperture, the outline of which is undulating. The ornaments vary in character according to the preservation, showing three states. If the shell is well preserved, as in uncompressed examples (fig. 4), they consist of very numerous sharp longitudinal riblets, standing up on a flat surface; on average specimens these are from 7 to 10 per line, but near the apex may be as many as 36 per line. If on the contrary the shell is as usual an internal cast showing the septa, the ornaments

appear as fine grooves of the same fineness as the riblets. The distinction between grooves and riblets is so obvious that one is tempted to consider these as distinct species, but all the other characters agree, and some examples may be seen in which the ornaments appear in the two forms on different parts of the same shell. It would thus appear that these lines were elevations both outside and inside of the shell, the latter impressing the cast as striæ; somewhat as we find in *O. originale*. Often, also, the fossil is entirely destitute of ornament, which on the above explanation is difficult to account for, unless it be the ornaments die off towards the aperture and are replaced by lines of growth. Nevertheless, one side of a fossil will lack the striæ, and the other side exhibit them perfectly. Failing, then, any other distinctive characters, these three appearances must be put down to differences of preservation. The septa are more or less undulating, but on the whole are direct. They are distant from $\frac{1}{6}$ to $\frac{1}{8}$ the diameter, according to the compression, though occasionally they are wider apart. Their convexity is about $\frac{1}{3}$ of the same. The siphuncle is $\frac{3}{5}$ across the diameter towards the more concave side when there is any curvature. Its elements are swollen between the septa, and are in earlier examples bulbous, but in the larger ones butt-shaped. There are organic deposits round the neck of the septa, also on their concave side, and something of the same character on the exterior of the siphuncular bulbs. The abundance of small annelid borings of spiral form which are constantly found on the surface of the body-chamber indicates that the animal was exposed to these parasites during life, notwithstanding the apparent thinness of its shell. The greatest diameter seen is about two inches, but nothing approaching a complete specimen has come under observation.

Relations.—The large size of this shell immediately separates it from the other British species that are similarly ornamented, and its ornaments are much finer than those of *O. filosum*. When ill-preserved, it has often been mistaken for *O. imbricatum*, which is a smooth shell and of an elliptic section, and it is to this latter that the isolated septal chambers, so often referred to the present species, belong.

Distribution.—Small examples occur in the Wenlock Shale of Llyn Alwin (2), Usk (2), and Dudley (1). Specimens have been seen from the Wenlock Limestone of Dudley (2), Usk (2), and Ledbury (1); from the Lower Ludlow of Presteign (1), Mocktree (1), and Dudley (2); from the Aymestry Limestone of Ledbury (2); from the Upper Ludlow of Presteign (2), Ludlow (12), Bradnor Hill (3), Woolhope (7), Ledbury (5), Radnor (1), Usk (1), and Kendal (10); from the Passage Beds, Kington, and in the Upper Silurian of Kerry.

The species is also recorded by M'Coy from Denbigh; by Phillips, from Marloes, Llandeilo, Builth, Tortworth, Abberley, and Malvern; by Hughes, from the Coniston Flags; by Strickland, from the Upper Ludlow, Hagley; and by Salter, from Longfields and Coalbrookdale.

Section Imbricati.

Orthoceras Avelinii, Salter, Pl. VI. figs. 1, 2.

1854. Orthoceras Avelinii, Salter in Murchison's 'Siluria,' Foss. fig. 4, p. 48.
1866. „ „ Salter, 'Memoirs of the Geol. Surv.' vol. iii. pl. 11 b, fig. 18, p. 356.
Syn. 1875. Orthoceras caereesiense, Hicks, 'Quart. Journ. Geol. Soc.' vol. xxxi. pl. 11, figs. 8–10, p. 189.

Type.—The examples in the Museum of Practical Geology, which give the data for Salter's description, are, no doubt, his types; but none of them agrees exactly in dimensions with his figure. The two specimens, which may form part of a single shell, give the following characters. The section is elliptic, the diameters being the ratio of 8 to 7. The rate of increase is 1 in 7 in both fragments. The ornaments on the smaller consist of undulating rounded elevations, rising on the side of the siphuncle, but no finer lines are preserved. On the other, these elevations are not proved, though the shell is more prominent at the septa, which might be due to the resistance to compression. The finer ornaments are upward imbrications, about 30 in the diameter of the shell, or from 4 to 8 per line, but rather irregular; they are a little oblique. The septa are parallel to them, but somewhat undulating, $\frac{5}{11}$ the diameter apart, corresponding, perhaps, to the elevations. The siphuncle is $\frac{1}{3}$ across the diameter on the side to which the septa rise. The united length of the specimens is $4\frac{1}{2}$ inches; greatest diameter, $\frac{7}{8}$ inch. From the Lower Llandeilo of Cefn Gwynlle, Shelve. In the Museum of Practical Geology.

General Description.—The section is not seen in any other examples. The rate of increase is seldom seen so great as in the type, owing, perhaps, to the specimens being mere surface-marks; and this is especially the case with those called *O. caereesiense.* The ornaments, in the form of low rounded elevations, are constantly present in the young shell and not always absent in the adult. The finer ornaments are well seen on the external cast figured by Dr. Hicks (loc. cit., fig. 10). At the smaller end they are nearly straight, and look from the inside more like broken edges of septa (which of course they are not) than ornaments: they are here 3 per line, which is not less than $\frac{1}{12}$ the diameter preserved, and that is doubtless only a fraction of the whole; towards the larger end they are closer, and are $\frac{1}{30}$ to $\frac{1}{35}$ the apparent diameter. Other examples from Shelve have similar curious imbrications, but usually these are worn off. The septa are not, but the position of the siphuncle is confirmed. The type is the largest seen.

Relations.—Dr. Hicks states that his *O. caereesiense* differs from *O. Avelinii* in being broader and having closer striæ. The breadth is merely due to their flattening

out, and in the specimen examined the part preserved is actually narrower, and the imbrications towards the smaller end are more remote in proportion than in the type. No other species imitates this closely enough for useful comparison.

Distribution.—In the Lower Llandeilo of Cefn Gwynlle, Shelve (6), Bogmine (2). Grit mine (1); in the Upper Llandeilo of Abereiddy (2); in the Upper Arenig of St. David's (3).

Dr. Hicks also records this from beds of similar age at Carnarvon.

ORTHOCERAS ASCENDENS, Blake, Pl. XII. fig. 7.

Type.—The section is circular, and there is a slight curvature of the shell; the rate of increase is 1 in 15. The ornaments are sharp, upward imbrications which cross the shell directly, without any undulation; they are distant about $\frac{1}{7}$ of a line or $\frac{1}{14}$ the diameter. The septa are not seen, but the siphuncle appears to be central. The diameter is 2 lines and the length 11 lines. From the Bala Beds of the Chair of Kildare. In the Museum of Practical Geology.

General Description.—Associated specimens, one perhaps the actual continuation of the type, show the curvature continued to near the apex, and the rate of increase as much as 1 in 11. The direct upward imbrications are from 18 to 6 per line, according to the diameter, but in proportion to the latter line they are closer in larger specimens. No further details of septa or siphuncle have been seen. The largest fragment has a diameter of 4 lines. With this species may be temporarily associated a specimen from the Upper Silurian, which has similar direct upward imbrications, rather approaching in character to grooves, distant $\frac{1}{4}$ line and parallel to the septa, the last four of which are but $\frac{1}{10}$ the diameter apart. The body-chamber slightly contracts towards the aperture. This may well be a distinct species, when all data of the present one are known.

Relations.—This species is separated from *O. subundulatum* on the ground of the upward imbrications being direct and not undulating, in which also it differs from *O. advena*; the ornaments are also closer, and the rate of increase less than in the former. It is nearly allied to *O. primum*, Barrande, but its rate of increase is less, and it is a smaller shell and has a central siphuncle; it is also curved.

Distribution.—In the Bala Beds of Kildare (3), and Knockshligon, co. Tipperary (1); in the Lower Ludlow of Ledbury, doubtfully.

Orthoceras subundulatum, Portlock, Pl. XI. figs. 8, 9, 10.

1843. Orthoceras subundulatum, Portlock, 'Geol. Rep.' pl. 28, fig. 2, p. 373.
1852. " " M'Coy, 'Pal. Fossils,' p. 317 (part).
1854. " " Salter in Murchison's 'Siluria,' Foss. gr. 62, fig. 3.
Syn. 1843. Orthoceras incertum, Portlock, loc. cit., pl. 28, fig. 7, p. 374.
1846. Creseis Sedgwickii, Forbes, 'Quart. Journ. Geol. Soc.' vol. i. p. 146, fig. 2.
1866. Orthoceras socium, Barrande, 'Syst. Sil. de Bohême,' pl. 222, 372, &c.
Query 1863. Orthoceras subundulatum, Haswell, 'Silurian Rocks of the Pentlands,' pl. 1, figs. 10, 14.

Type.—The specimen is flattened, so that the diameters are in the ratio of 3 to 1. The rate of increase of the flattened shell is 1 in 8. The ornaments are upward imbrications which have an undulating course, but no general obliquity; they are from 3 to 4 per line, but there are 3 or 4 smaller ones between each; towards the apex the smaller alone are present. There are still deeper lines at irregular distances, from $1\frac{1}{2}$ to $\frac{3}{4}$ of a line apart, which are not seen at the smaller end. These have been taken for indications of septa, which they very much resemble, but, as they are only seen on part of the shell, have an undulating outline parallel to the smaller ornaments, and are not regularly spaced; they are more probably mere variations of the finer imbrications. If this be so, the septal characters are not shown. The length is $\frac{7}{8}$ inch and the greatest diameter $\frac{3}{8}$ inch. From the Bala Series of Fermanagh. In the Museum of Practical Geology.

General Description.—The section has been seen to be circular in one example and nearly so in another. The rate of increase is very variable, not only on account of the compression, but in individuals from the same locality. The average is that of the type, but in some it is 1 in 6, in others, more rarely, 1 in 20. The ornaments are characteristic, well-marked upward imbrications. These have an undulating course, with very slight general obliquity; their distance is variable on the same specimens, but is seldom more than $\frac{1}{4}$ line. In the body-chamber there are, in one, broad undulations marked by the greater and less distance of the ornaments in series. One specimen shows a curious feature on one side, consisting of lines which undulate in a contrary direction to the ordinary ornaments, and thus bound a set of diamond-shaped transverse depressions; others show more elongated depressions (fig. 10), but all these may be due to the flattening of the shell. The body-chamber is at least as long as its basal diameter, but the aperture has not been seen. The septa are direct and distant $\frac{1}{6}$ of the longer diameter of the examples showing them. The ornaments are seen not to be parallel to the septa, but to cut them in their undulations; about 3 or 4 ornaments cross one chamber. The last two or three septa are closer than the rest. The siphuncle has not been certainly seen, but a small septal surface,

close to a specimen of this species and apparently broken from it, shows it small and subcentral. The examples are usually small.

Relations.—Portlock's *Orthoceras incertum* presents but few distinctive features, and may well belong to the present species, as their author thought possible. Authors have agreed that the *Creseis Sedgwickii* of Forbes is a synonym of this species, but I have not discovered the original. The *Orthoceras socium* of Barrande is, like our species, a widely spread one, both in time and space; and though it grows to be of larger size, and the septa are usually much more remote, the ornaments are so similar that one can scarcely doubt that *O. subundulatum* represents one of its varieties. The other species of the group with upward imbrications are distinguished either by the greater obliquity of the ornaments or their want of undulation. The minor peculiarities of ornament which have been described in the type are not repeated in any of the other specimens, all of which are from Upper Silurian, while the type is from the Lower. It is possible, therefore, that we may be dealing with two distinct species, which can only be proved by better specimens from the typical locality.

Distribution.—In the Bala Series of Fermanagh (2); in the Wenlock Shale of Wenlock (1), Barrington (4), Oernant (1), Builth (4), Garcoed, Usk (7), Llanbadarn (1), Nantglyn (1), Llansannan (1), and Garragrena, co. Tipperary (1); in the Coniston Flags of Horton (1) and Hawkshead (1); in the Coniston Grit, Howgill (1); in the Denbigh Flags, Llangynyw (2) and Moel Seisiog (1); in the Lower Ludlow of Ludlow (5 and 2 doubtful), Elton (1), Aymestry (1), Ledbury (1); and in the Upper Ludlow of Ludlow (2). Also in the Upper Silurian of Derrymore Glen, co. Kerry (2).

The name of *O. subundulatum* has been used for all species whose transverse lineation had at all an undulating character, irrespective of whether they were imbricating or not, and the recorded occurrences do not necessarily refer to our present species. Thus it is stated by Wyatt-Edgell (Geol. Mag. iii. p. 161) to occur in the Llandeilo Beds of South Wales; this may very probably mean a fine variety of *O. Avelinii.* It is recorded by M'Coy from the Upper Bala, Ashgill, Builth, and Dent; and from Lower Silurian schists, Tirnaskea, Pomeroy: by Baily from the same horizon at Kilmoksilla (Sheet 133): by Davies from the Bala Beds, Llanrwst: by Salter from the Upper Llandovery, Craighir, and three other localities, —from the Wenlock Shale, Frid-y-fedwen and Capel-y-shiw; from the Lower Ludlow, Coalbrookdale; from the Coniston Flags, Froshow Fell, Casterton Fell, and High Hollins: by Harkness from Balmae, Kirkcudbright: by Brown and Henderson from the Upper Silurian of the Pentlands; from Blair Farm in the Catalogue of Western Scottish Fossils: and by Baily from Upper Silurian rocks of Caherconree, co. Kerry.

ORTHOCERAS FRETUM, Blake, Pl. XIV. figs. 7, 7*a*, 7*b*.

Type.—The section is very nearly circular, but the diameter in the direction of the slope of the septa is a little longer than the other. The rate of increase is 1 in 10. The body-chamber is short, its length not being greater than $1\frac{1}{3}$ times the basal diameter. It has a well-marked constriction below the aperture, which is otherwise simple. The shell has very close upward imbrications, 20 per line, which get broken off in a peculiar, jagged way; they are nearly direct, but, if anything, slope in a direction opposite to that of the septa. These have not a greater obliquity than 4°, and have a convexity of more than $\frac{1}{5}$ the diameter. Their distance is less than $\frac{1}{8}$ of the same. The siphuncle is of moderate size, situated on the longer diameter $\frac{3}{7}$ across it, towards the side to which the septa slope back. The greatest diameter is $1\frac{1}{3}$ inches; the length is 3 inches. From the Upper Ludlow, Turner's Hill. In the Museum of Practical Geology.

General Description.—The other examples referred to this species only doubtfully belong to it. One has a length of 11 inches, and its septa $\frac{1}{6}$ the diameter apart with an excentric siphuncle. The others only show similar imbricating transverse lines of growth, very close together, but none show the aperture.

Relations.—This has been referred to *O. imbricatum*, to which in its septal and siphuncular characters it bears great resemblance; but in length of body-chamber, and in the constriction beneath the aperture, it is clearly distinct, and the ornaments are more conspicuous than in that species. From *O. pomeroense* and *O. mocktreense* the position and character of the siphuncle, when seen, separate it. It thus appears that fragments of any of these shells would be undistinguishable.

Distribution.—In the Wenlock Shale of Barrington (1)? in the Aymestry Limestone of Usk (1)? in the Upper Ludlow of Ludlow (1), and in the Upper Silurian of Kirkcudbright Bay (2)?

ORTHOCERAS SATURNI, Barrande, Pl. XI. figs. 6, 6*a*.

1868. ORTHOCERAS SATURNI, Barrande, 'Syst. Silur. de Bohême,' pl. 255, 264, p. 601.

Type.—The section is at first circular, but becomes elliptic towards the body-chamber; the ratio of the axes being as 5 to 6, and the longer one transverse. There is a slight curvature towards the apex in the plane of the minor axis. The rate of increase is about 1 in 6 for the major axis, and 1 in 10 for the minor. The body-chamber is twice the length of its mean basal diameter. The aperture is horizontal and simple, and there is a feeble constriction below it. The ornaments consist, first, of very irregular transverse lines, which become more and more lamellose with age, and have a curious zigzag course; next, of feeble irregularly spaced longitudinal lines, which die away towards the larger end; and lastly, of a number of small pits

in the intervals between the others, having raised boundaries, and of elliptic shape, with the long axis transverse. The septa are more or less oblique up to 30°, sloping back to the more convex side; they are distant at first $\frac{1}{5}$, but at last $\frac{1}{10}$ the diameter; the convexity is about $\frac{1}{3}$ the diameter. The siphuncle is $\frac{1}{6}$ the same, and is situated $\frac{3}{8}$ across the minor axis, sometimes nearer the convex and sometimes nearer the concave side. The greatest length is $10\frac{1}{2}$ inches, and the greatest diameter nearly 2 inches. The species is found both in stage D and in the band E_2 of stage E of the Silurian of Bohemia.

General Description.—The peculiar ornaments of this species are very closely reproduced in the specimen figured, which agrees with Barrande's species in other respects also; other examples, which show only the curious lamellar transverse lines, are assumed to belong to the same, though the pitting of the surface is not noticed in all. The section is usually flattened, but in one example it is truly circular. The rate of increase in the figured example is 1 in 10, but this character must be very variable, actual measures on compressed specimens giving from 1 in 5 to 1 in 24. No body-chamber or aperture has certainly been seen. In the figured example there are a number of oval depressions with the longer axis transverse and twice the shorter, the latter being $\frac{1}{20}$ of a line; their boundaries are raised, and tend to run into irregular longitudinal lines, but the transverse lines are obscure. In other examples the lamellæ, broken off upwards in a jagged line, are conspicuous, and there are signs of longitudinal lines. The septa are 7° oblique, curving forward by compression, and are $\frac{1}{6}$ the longer diameter apart. The septal surface and the siphuncle have not been seen. The greatest length seen is $4\frac{1}{3}$ inches, and the usual diameter a little more than an inch; but one example perhaps belonging to this has a longer diameter of $4\frac{1}{2}$ inches. This, however, may be a peculiar form of *O. fimbriatum.*

Relations.—The peculiar pitting of this figured example, and the remarkable zigzag lamellæ of the others, mark off the species very distinctly; but *O. mocktreense* is not far removed. In one example of that species a peculiar network is observed, which may, indeed, be due to *Polyzoa,* but in any case the longer axes are longitudinal. The tapering and the siphuncle, and the regularity of the lines of growth, would also differentiate it. The pitting is too fine and too well marked for ordinary examples to be thought to be *O. fimbriatum* with the lamellæ run together, but the old example might possibly be so considered.

Distribution.—In the Lower Ludlow of Leintwardine (2), and in the Aymestry Limestone of Mocktree (1); also in the Lower Silurian of Portraine (1); the large and doubtful example from the Lower Llandovery Beds of Thrave in the Girvan district.

ORTHOCERAS MOCKTREENSE, Sowerby, Pl. XV. figs. 6, 6*a*, 6*b*;
also Pl. X. figs. 2, 6, and Pl. XI. fig. 3.

1838.	ORTHOCERAS	MOCKTREENSE,	Sowerby in Murchison's 'Silurian System,' pl. 6, fig. 11, p. 606.
1848.	,,	,,	Phillips and Salter, 'Mem. Geol. Surv.' vol. ii. pt. i. p. 353.
1852.	,,	,,	M'Coy, 'Palæozoic Fossils,' p. 315.
1873.	,,	,,	Salter, 'Cambrian and Silurian Fossils,' p. 158.

Type.—The section is very nearly circular, the ratio of the diameters being 21 to 20. The rate of increase is perhaps 1 in 13. The whole specimen is septate. The ornaments consist, first, of well-marked somewhat undulating fine upward imbrications, like lines of growth: secondly, of very fine lines parallel to these, about 30 per line; over all this is seen a curious network of polygonal cells arranged quincuncially, with their long axes longitudinal, about three per line transversely. This appearance may be due to the former overgrowth of some polyzoon, but it is very uniform on the surface. The lines of growth are irregular in places, from mending. The septal distance can only be judged by the longitudinal diameter of the siphuncular bead; this gives it as $\frac{3}{8}$ the diameter. The siphuncle has its centre about $\frac{3}{8}$ across the diameter, and is inflated to a bead between the septa, where it is nearly $\frac{1}{3}$ the diameter; it is therefore rather longer than broad: exteriorly, but perhaps from preservation, it has a mammillated surface. This specimen is very remarkably preserved, one half being dark, the other light, the division between the two colours corresponding to a crystalline plane. Length, 2 inches; diameter, nearly 1 inch. From the Lower Ludlow of Mocktree. In the Collection of the Geological Society.

General Description.—The preservation of the type is so peculiar that it is difficult to identify with it specimens which are preserved in the ordinary way. The most important examples are therefore figured (Pl. X. figs. 2, 6; Pl. XI. fig. 3). These are all characterised by a general similarity of ornaments, but the bulbous siphuncle is only seen in other examples. The section is circular, and the rate of increase generally about 1 in 10 in small specimens, decreasing to very little in the body-chamber. The latter, in the large example (Pl. XI. fig. 3), is $3\frac{1}{2}$ times its basal diameter, and is slightly contracted before the aperture is reached. The ornaments are essentially upwardly imbricating lines of growth, with finer intermediate lines, but the polygonal network is not seen again. The septa are on the whole direct, though a little undulating, and are distant $\frac{1}{3}$ to $\frac{2}{9}$ the diameter. Some examples show a bulbous siphuncle $\frac{2}{5}$ across the diameter. The largest has a diameter of $3\frac{1}{2}$ inches, and a length of $12\frac{3}{4}$ inches.

Relations.—The bulbous siphuncle when seen is sufficient to distinguish this species. It is allied, except for this, to *O. Saturni*, whose ornaments differ but

slightly. It might also be taken for *O. ludense*, but its lines of growth are really ornaments, and its rate of increase is greater. It has no relation to the specimens called *O. Brightii*, which have been referred to it, except that the siphuncles of both have been figured, though essentially dissimilar.

Distribution.—In the Lower Ludlow of Mocktree (2) and Ledbury (2); in the Aymestry Limestone of Usk (5); in the Upper Ludlow of Ledbury (2), Underbarrow (1), and Brigsteer (1).

It is also recorded by Salter, from the Wenlock Limestone of Ledbury.

ORTHOCERAS REVERSUM, Blake, Pl. XI. fig. 7.

Type.—The specimen is flattened, and the breadth as thus seen increases at the rate of 1 in 5. No characters, either of body-chamber or septa, are seen. The ornaments consist of very remarkable transverse, nearly direct downward imbrications. These are somewhat irregular, and are alternately stronger and weaker; but each one, as traced round the circumference, is weak in one place and strong in another; they are $\frac{1}{18}$ the diameter apart. The diameter is $1\frac{1}{4}$ inches, and the length about 1 inch. In a mudstone, probably Ludlow matrix; locality unknown. In the Museum of Practical Geology.

General Description.—Two other specimens show the same remarkable ornaments, but give no further information. The imbrications are downwards, and distant $\frac{1}{15}$ to $\frac{1}{18}$ the flattened diameter, and are thus wide enough apart to give a ribbed aspect to the shell, the intervening spaces being prominent. One of these presents a somewhat spotted appearance, as if some membrane had covered it.

Relations.—This species is nearly allied to *O. Maclareni*, to which the specimens in question have been referred, but the imbrications are distinctly downwards, and are nearly direct; they have also a peculiar form and irregularity of development which entirely distinguishes them.

Distribution.—The only certain locality is the Lower Ludlow of Leintwardine (1). The other specimens are from the Wenlock Shale? of Llanbadarn (1), and the Upper Ludlow? of unknown locality.

Section Læves.

ORTHOCERAS SERICEUM, Salter, Pl. XIII. figs. 1, 2.

1866. ORTHOCERAS SERICEUM, Salter, 'Memoirs of the Geological Survey,' vol. iii. pl. 10, figs. 4, 5, p. 356.
1873. ,, ,, Salter, 'Cambrian and Silurian Fossils,' p. 18.
1873. ORTHOCERAS, sp., Hicks, 'Quart. Journ. Geol. Soc.' vol. xxxix. pl. iii. fig. 27, p. 51.

Type.—Two specimens are figured by Salter, both of them flattened in the slate.

The flattened indication of the first has a rate of increase of 1 in 33; but owing to the obvious distortion which the specimen has undergone, no reliance can be placed on the measurements. About 1 inch of body-chamber is seen without an end, nor is any end seen in the second example. The surface of the latter may have been a little rugose transversely towards the aperture, or the appearance may be due to pressure. The septa have now an obliquity of 33° in one and of 45° in the other. In the smaller they are $\frac{1}{6}$ the diameter apart, but in the larger, at last, $\frac{1}{21}$ only. The siphuncle appears to be indicated by a nearly central festooning of the septa, where they may be supposed to grasp it; it is not very broad. The length of the smaller is $2\frac{3}{4}$ inches, and the diameter of the larger $\frac{3}{4}$ inch. From the Upper Tremadoc of Garth. In the Woodwardian Museum.

General Description.—The specimens of this species have all suffered compression and an unknown amount of contortion, and their surface may also be subsequently crinkled; the true characters of the species are therefore obscure. The rate of increase is slow, but ranges in actual specimens between 1 in 8 and 1 in 31. The body-chamber is not certainly seen. The septa are always oblique; the amount varies actually from 7° to 45°, and they vary in their observed distance from $\frac{1}{5}$ to $\frac{1}{15}$ the apparent diameter. The siphuncle is seen in one example to be nearly lateral, but this is probably a matter of pressure; the rest show it central and moderate in size, always supposing that the festoon in the septa indicates it. The largest is $3\frac{3}{4}$ inches long and $\frac{5}{6}$ inch in diameter.

Relations.—Though much variation occurs in actual specimens, there is nothing to differentiate them definitely. The nearest approach to this species is made by *O. audax* of the Bala Beds, but considering its unflattened state its rate of increase is more rapid. If it were not for the obliquity of the septa, which after all may be due to distortion, this species, in its slow growth, numerous septa, and central siphuncle, is well fitted to be the primeval form.

Distribution.—The examples seen are from the Upper Tremadoc of Llanerch (1), Garth (9), Tremanhere, St. David's (1), and a more doubtful specimen from Arenig Beds, Portmadoc (1).

It is also recorded by Dr. Hicks, from the Middle Arenig, Whitesand Bay.

Orthoceras pertinens, Blake, Pl. III. fig. 11.

Type.—The shell is depressed, so that the section is elliptical and rather flat on the surface exposed. The rate of increase of the long diameter is 1 in 10. The surface exposed is without ornament, and the line of junction with the stone is perfectly uniform. The septa are direct and have very little convexity; the distance is about $\frac{1}{4}$ the diameter. The siphuncle is central, and very moderate in size, but there are signs of organic deposit about the necks. The length preserved is

$4\frac{1}{2}$ inches, and the greatest diameter is $\frac{3}{4}$ inch. From the Durness Limestone. In the Museum of Practical Geology.

General Description.—Another example associated with this confirms the general proportions and the distance of the septa, and affords no signs of any ornaments.

Relations.—It is possible that these are the specimens supposed by Salter to prove that *O. mendax* was smooth when young, yet they are larger than other specimens of the latter species which show the ribs, and cannot belong to it if the siphuncle be any guide. It is certainly to be expected that some unornamented species should occur in these rocks. The difference between this and what *O. sericeum* may be supposed to have been is not great, the chief one being the more rapid increase and more distant septa. The latter character separates it from *O. audax*, its nearest ally of later date.

Distribution.—In the Lower Llandeilo of Durness (2).

Orthoceras vagans, Salter, Pl. XIII. figs. 10, 11, 12.

1848.	Orthoceras	vagans,	Salter in Sharpe on the Geology of Oporto, 'Quart. Journ. Geol. Soc.' vol. v. pl. 6, fig. 6, p. 153.
1852.	„	„	Salter, Appendix A, M'Coy's 'Palæozoic Fossils,' p. vi. pl. 1 L, figs. 28, 29.
1852.	„	„	M'Coy, 'Pal. Foss.' p. 318.
1857.	„	„	Salter in Murchison's 'Siluria,' Foss. gr. 42, fig. 1.
1866.	„	„	Salter, 'Mem. Geol. Surv.' vol. iii. pl. 24, figs. 1–5, p. 356.
1873.	„	„	Salter, 'Cambrian and Silurian Fossils,' p. 70.
—	„	„	Baily, 'Characteristic British Fossils,' pl. 12, fig. 11.

Type.—The author's description is: "Smooth; long tapering when young, more conical when old; septa broad elliptical, oblique on the longer axis, moderately distant in the young shell, distant by more than the diameter in mid-age, and by less than one-fourth of the diameter when old, deep cup-shaped; siphuncle nearly central." From the Lower Silurian rocks of Oporto. I have not seen the original specimen, but the figure shows a rate of increase of 1 in 10, and the septa are distant more than the diameter. This figure must be taken as the type, for Salter has, I think, derived his description from several specimens which may not belong to the same species. In particular there is one in the Woodwardian Museum, so labelled by him, which expands at the rate of 1 in 6, and its septa are $\frac{1}{5}$ the mean diameter apart; there is no proof of this belonging to the same species, but it appears to be the authority for the statements "more conical when old," and "septa distant less than $\frac{1}{4}$ the diameter when old."

General Description.—The section is more nearly round in small specimens than at a later stage, when it becomes subquadrate and compressed in the ratio of 7 to 6.

Some young forms show a little curvature (fig. 6). The rate of increase lies between 1 in 9 and 1 in 13, and in the largest specimen, figured by Salter, is reduced to 1 in 22, and in none does it increase to 1 in 5 or 6. The body-chamber is not certainly known, as the specimens last referred to may be all septate. The exterior is seldom preserved, and shows only lines of growth. The septa have considerable convexity, viz. from $\frac{1}{3}$ to $\frac{2}{5}$ the diameter; they are slightly undulating and oblique; their distance apart constitutes the peculiar feature of the species, as it is essentially variable: on the same specimen it changes from $\frac{1}{3}$ to $\frac{2}{3}$ the diameter, and in others from 1 to 2 diameters; the distance is not, however, constant for more than 2 septa, the average being more than $\frac{1}{2}$ the diameter. The siphuncle is small, and situated on the most convex part of the septum, or about central in a transverse diameter. On one specimen (fig. 5) are two oblique grooves, $\frac{1}{2}$ inch apart, of trapezoidal section, as in *O. Etheridgii;* and in another some curvature is shown towards the apex, which exposes the cicatrix very clearly; none of these have more than $\frac{1}{2}$ inch diameter. The greatest diameter seen is $1\frac{1}{2}$ inches, and the longest specimen measures 5 inches.

Relations.—The variability of the distance of the septa does not justify the inclusion of specimens containing moderately close septa throughout, and this character separates most species. In *O. distans* the septa, though distant, are more regular, and the siphuncle is excentric. This latter character differentiates also *O. politum.* The quadrate section is also a peculiarity of the present species. The name *O. remotum* appears to have been used by Salter in the first instance, under which name the species is quoted by Baily, but subsequently it was changed.

Distribution.—The smaller forms are found in the Lower Llandeilo flags of Cefn Gwynlle, Shelve (12), but the majority are from the Bala Series at Rhiwlas, Bala (18); they occur also at Troutbeck (1), Dufton (1), and Coniston (1), and perhaps at Desertcreat (1), and the Chair of Kildare (2).

Harkness and Nicholson record it also from the Keisley Limestone, and Baily mentions it from the Lower Silurian of Portraine. Its occurrence in Spain was noticed at its first establishment. Perhaps Barrande's *O. curvens* represents the same species in Bohemia.

Orthoceras politum, M'Coy, Pl. IX. figs. 1, 2, 8.

1851. Orthoceras politum, M'Coy, 'Ann. Nat. Hist.' Series ii. vol. vii. p. 45.
1851. „ „ Salter in Murchison, 'Quart. Journ. Geol. Soc.' vol. vii. p. 137, pl. 10, figs. 5, 6.
1852. „ „ M'Coy, 'Palæozoic Fossils,' pl. 1, fig. 30, p. 316.
1865. „ „ Haswell, 'Silurian Rocks of the Pentlands,' pl. 1, fig. 1.
1873. „ „ Salter, 'Cambrian and Sil. Fossils,' p. 70.
Syn. 1846. Orthoceras acuarium, M'Coy, 'Sil. Foss. Ireland,' p. 7 (not of Münster).

1870. ORTHOCERAS LANCEA, Barrande, 'Syst. Sil. de Bohême,' pl. 379, 411, p. 640.
1870. „ LENTUM, Barrande, loc. cit., pl. 421–2, p. 641.
Query 1843. KOLEOCERAS PSEUDOSPECIOSUM, Portlock, 'Geol. Rep.' p. 380, pl. 26, fig. 3.
1870. ORTHOCERAS POTENS, Barrande, loc. cit., pl. 386, p. 540.

Type.—The section is not well seen, the fossil being imbedded in the stone, but it appears to be somewhat compressed. The rate of increase is 1 in 18, which remains pretty constant throughout the length. No details of body-chamber can be observed; possibly it is not reached. The shell surface was probably smooth, though it has been *rubbed*. The septa are direct, and distant throughout about $\frac{1}{2}$ the diameter, and their convexity is $\frac{1}{4}$ the same. The siphuncle is not properly seen, and looks nearly central at the smaller end. In another specimen (fig. 2), which was probably also used as type, the section is circular, and the siphuncle at one end is $\frac{1}{3}$ across the diameter, though central at the smaller end, and has itself a diameter of $\frac{1}{6}$ the whole, while the septa slightly undulate on the siphuncular side. The larger of these specimens has a length of more than 18 inches, and its greatest diameter is $1\frac{1}{4}$ inches. From the Bala Beds of Glenwhapple, Ayrshire. In the Woodwardian Museum.

General Description.—Though several examples have a truly circular section, most have the radii slightly unequal. The rate of increase is invariably slow, in no example exceeding 1 in 11, and often much less than in the type. The body-chamber was almost cylindrical, and appears to have attained a diameter of at least $3\frac{1}{2}$ inches, and perhaps more, though it is difficult to prove to what species isolated body-chambers belong, even when occurring in the same beds with the type. The septa are generally direct, as seen, but often show some undulation or an obliquity up to 5°. Their distance is from $\frac{1}{2}$ down to $\frac{1}{3}$ the diameter, and is only occasionally variable, but may be greater in youth. They have a convexity of $\frac{1}{3}$ to $\frac{1}{4}$ the diameter. The siphuncle is very nearly central in the young shell (fig. 2*a*), but with growth it takes an excentric position $\frac{1}{3}$ from the side (fig. 2*b*); in some examples, whose axes are unequal, it is unsymmetrically situated (fig. 8). Its diameter is from $\frac{1}{7}$ to $\frac{1}{6}$ of the whole diameter, and it was probably continuous. The type is the longest example known. The greatest diameter of the septal portion is $1\frac{1}{2}$ inches.

Relations.—This species differs from *O. vagans* in the regularity of its septa and the excentricity of its siphuncle; it moreover increases less rapidly. The difference between this and *O. distans* is not very great; in the latter the septa are always more than $\frac{1}{2}$ the diameter apart, and in the present one that is their maximum. The section also of *O. distans* is less circular, and it is a more robust shell. Its excentric siphuncle differentiates this from *O. ludense* and from *O. primævum*. It is stated in Sir R. Murchison's paper (loc. cit.) that Barrande recognised the specimens described by Salter as one of the Bohemian species

familiar to him. Barrande, however, makes no reference to M'Coy's species, but figures and describes *O. lancea* with identical characters, and the distinctions relied on to separate from the latter *O. lentum* and *O. potens* would not be sufficient for me. The example referred by M'Coy to *O. acuarium,* Münster, may very probably be a young form of this species. Its rate of increase is 1 in 15. The septa are $\frac{2}{3}$ the diameter apart, and the siphuncle is $\frac{2}{5}$ along the diameter, and appears as a continuous tube. It therefore has a far greater rate of increase than the species referred to by M'Coy, and a non-central siphuncle. The imperfect specimen named by Portlock *Koleoceras speciosum* may probably belong to the present species.

Distribution.— In the Bala Beds of Glenwhapple, Ayrshire (10); in the Coniston Limestone, Troutbeck (1); in Lower Silurian beds of Desertcreat (1), Clare (1), Portraine (1), Waterford (1), Cong (1), Blackwater Bridge (1), and possibly two species from Kirkcudbright (4).

It is also recorded by Geikie, from Bala Beds at Carrick; by Davies, at Llechwyd, Nant Iorweth, and Glynceirog; by Geikie, from the Coniston Limestone, Keisley; and from Craig Head, in the Catalogue of Western Scottish Fossils.

ORTHOCERAS AUDAX, Salter, Pl. XII. fig. 8.

1866. ORTHOCERAS AUDAX, Salter, 'Memoirs of the Geological Survey,' vol. iii. pl. 24, fig. 7, p. 357.

Type.—Section nearly circular, the diameters in the ratio of 8 to 7; rate of increase 1 in 6. The whole is septate, and no external ornaments are visible. The septa are slightly undulating, rising on one of the narrow sides; their convexity is very slight, and their distance a little more than $\frac{1}{7}$ the longer diameter. The siphuncle is not seen in this specimen. Greatest diameter, $\frac{2}{3}$ inch; length, nearly 2 inches. From the Bala Beds of Rhiwlas Bala. In the Museum of Practical Geology.

General Description.—In some examples there is an appearance of squareness about the section, and the diameters are always unequal: when most so, they are in the ratio of 11 to 9. The rate of increase is 1 in 5 to 1 in 7. No body-chamber has been seen. The septa undulate to an amount of $3\frac{1}{2}°$, being highest on the narrow side; they are very slightly convex or almost flat, and most are $\frac{1}{8}$ to $\frac{1}{9}$ the diameter apart, but they may be more remote. The siphuncle is very slightly excentric on the long axis towards that side to which the septa rise; its diameter is small. The largest fragment has a diameter of 1 inch.

Relations.—Salter states that the specimens referred by M'Coy to *O. gregarium* (Sow.), which come from the Bala Limestone of the Chair of Kildare, belong to this species; but those preserved in the Museum of Practical Geology show very

convex septa, and a circular section with central siphuncle, which features are inconsistent with the characters of the present species; such differences, as well as its closer septa, separate it from Sowerby's true species. The closeness of its septa and general characters place it very near to *O. excentricum*, from which its greater rate of increase appears to differentiate it. Some Bohemian species, as *O. insons*, are similar to this; but they appear to have a slower rate of increase. It seems very probable that some of the Lower Silurian forms referred to *O. gregarium* may belong here, but it cannot be said to be proved.

Distribution.—In the Bala Series of Rhiwlas, Bala (8), and at Sandley (1), and probably also in the Lower Silurian of Waterford.

ORTHOCERAS PICTUM, Blake, Pl. XIII. fig. 5.

Type.—The section is circular, and the rate of increase is 1 in 6. Details of body-chamber are not shown. The shell is perfectly smooth on the surface, but shows longitudinal bands of colour, alternately white and brown, some wider and some narrower, about 12 per diameter. The septa appear to be direct, and to have a convexity of $\frac{1}{4}$ the diameter. The siphuncle is central and moderate in size. The diameter is 1 inch, and the length nearly 3 inches. From the Bala Series of Bala. In the Museum of Practical Geology.

General Description.—The other examples being fragmentary, no confirmation of the form is possible, but in the body-chamber the rate of increase is perhaps less. The aperture is bounded by an undulating curve without any constriction below. The body-chamber is probably longer than its basal diameter, as no septa are seen in the specimen showing the aperture. The colour bands are variable in their distance and breadth, the dark colour being as broad as the light. The greatest diameter seen is $1\frac{2}{3}$ inches.

Relations.—The presence of coloured bands may be held to differentiate this species from others. Nevertheless, a comparison must be made with such as have not yet shown their surface, as, for example, *O. audax*, which agrees in the rate of increase and the slight convexity of the septa; but it has a less circular section, and the septa undulate, while the siphuncle is slightly excentric. These differences, though small, relieve us from uniting the species without proof of coloured bands on *O. audax*. The central siphuncle distinguishes our species from *O. pellucidum*, Barrande, which is similarly coloured.

Distribution.—In the Bala Series of the Bala district (4) and of Acton Scott (1). The specimens are in the Museum of Practical Geology, and of Owens College, Manchester.

Orthoceras druidii, Blake, Pl. XV. fig. 2.

Type.—The shell is probably compressed, so that the diameters are as 10 to 9; and there is some little curvature. The rate of increase is in the compressed form 1 in 5. The body-chamber is shorter than its basal diameter, if all is preserved, and there is a contraction near the aperture, which is, however, probably due to pressure; the cast is smooth. The septa are oblique 13°, rising towards the more convex side, and are distant $\frac{1}{5}$ the diameter. Greatest diameter, 10 lines; greatest length, 2 inches. From the Bala Beds of Cerrig-y-druidion. In the Museum of Practical Geology.

General Description.—I am not certain whether any other specimens are known. If the curvature is an essential feature, there certainly are not; but there are some examples with an oblique septa at the same proportionate distance, showing a much slower tapering, and the siphuncle $\frac{3}{7}$ across the longer diameter.

Relations.—The great obliquity of the septa sufficiently marks off this species, and is the feature which renders it worth notice.

Distribution.—In the Bala Beds of Cerrig-y-druidion (1), Bala (2), and Marshbrook (1). There is also a large example in the Museum of Practical Geology, said to be from the Upper Ludlow of Radnor, showing an equal obliquity of septa, which may, however, be due to contortion.

Orthoceras ardvellense, Blake, Pl. XII. fig. 1.

Type.—The specimen is somewhat compressed, so that the outline is irregular, being flattened on one side, and the diameters are in the ratio of 3 to 2. The rate of increase of the long diameter is 1 in 8, and this includes the body-chamber, which is about twice the length of its basal diameter; but the aperture is not reached. The septa are slightly undulating, but on the whole are direct across the broader surface. Their distance is $\frac{1}{7}$ of the longer diameter. No siphuncle is seen: there are folds across the middle of each chamber parallel to the septa. The length is 6 inches, and the greatest diameter $2\frac{1}{2}$ inches. In a brown ferruginous grit, said to be from Ardwell, and of Bala age. In the Museum of Practical Geology.

General Description and Relations.—No other example corresponding to this having been met with, the species cannot be considered as satisfactorily established. It belongs to the *O. imbricatum* group, and is most like the specimen figured by Phillips as *O. marloense*; but if the septa were really oblique, this should appear on the flattened side. Moreover, the rate of increase is kept up in the body-chamber, which it is not in *O. imbricatum*. It therefore seems advisable to separate the species, which may be considered as the precursor of the last-named.

Distribution.—In the Bala Series, Ardwell (1).

ORTHOCERAS SUBGREGARIUM, M'Coy, Pl. XII. fig. 6.

1846. ORTHOCERAS SUBGREGARIUM, M'Coy, 'Sil. Foss. of Ireland,' pl. 1, fig. 4, p. 9.

Type.—I have not been able to discover this among the others in Sir R. Griffiths's collection in the Royal Dublin Museum, but the author's figure and description are very definite. The section is elliptic, the diameters being as 5 to 4. The rate of increase of the longer diameter is 1 in 18. The whole is septate, and the surface is not seen. The septa are direct, and have a medium convexity equal to the distance of the sutures, which is about $\frac{1}{4}$ the long diameter. The siphuncle is on the short diameter, $\frac{1}{3}$ of that line from the side. It is too large to be called filiform. The greatest diameter is $\frac{1}{2}$ inch, and the length is $1\frac{1}{2}$ inches. From the Bala quartzites, Cong.

General Description.—Some fossils from the same series in Ireland and elsewhere may perhaps be referred to this type. The section is either circular, or has axes in the ratio of 7 to 6. Some slight curvature is seen in one example. The rate of increase of the long diameter varies between 1 in 15 and 1 in 19. One shows a body-chamber of $2\frac{1}{3}$ inches, which is more than twice the basal diameter, and the aperture, which has no constriction beneath it, has an undulating outline. There are only obsolete and oblique lines of growth. The septa are slightly oblique in a direction opposite to the slope of the aperture, and have a moderate convexity. Their distance is from $\frac{1}{4}$ to $\frac{1}{5}$ the diameter. In the case of the example showing the aperture, only the two last septa are seen, which may be closer than the rest. The siphuncle is situated from $\frac{2}{7}$ to $\frac{1}{4}$ the diameter from the side, and when the axes are unequal lies on the shorter. Its diameter is $\frac{1}{6}$ of the whole, and its elements are cylindrical. The largest diameter is more than 1 inch, and the greatest length $2\frac{1}{3}$ inches.

The identification of this species is not a very satisfactory one, as the examples seen give the characters separately, and none unites them all.

Relations.—There is nothing to distinguish some of these from *O. politum* except the distance of the septa; the figured specimen indeed might belong to the latter species, if it were proved that in it the last two chambers were only half as deep as the rest.

Distribution.—In the Upper Arenig of St. David's? (1); in the Bala Series of Bala (3), and of Kildare (1); in the Upper Llandovery of Boocaun (1), of Llandovery (1), and Coldbrook (1), and perhaps in the Shales of Kirkcudbright Bay (1).

This species is recorded also by Kelly from Leenane, Munterowen, and Ardaun; also by Baily, as from the Upper Llandovery of Cong, and the Bala Limestone of the Chair of Kildare; and in the Catalogue of Western Scottish Fossils, from Drummuck.

ORTHOCERAS GREGARIUM, Sowerby, Pl. XV. figs. 4, 5.

1839. ORTHOCERAS GREGARIUM, Sowerby in Murchison's 'Silurian Syst.' t. 8, fig. 16, p. 619.
1846. " " M'Coy, 'Sil. Foss. of Ireland,' p. 8.
Syn. 1866. ORTHOCERAS NOVELLUM, Barrande, 'Syst. Sil. de Bohême,' pl. 218, 396.

Not 1843. ORTHOCERAS GREGARIUM? Portlock, 'Geol. Rep.' pl. 27, fig. 8.

Type.—The specimens in the Museum of the Geological Society, which are labelled as having been figured, do not accurately agree with the figure quoted above, which appears to have been made up of several. There is, therefore, no authentic type specimen. In these fragments the section is apparently circular, but, perhaps, not quite so. The rate of increase of the earlier portion is 1 in 7, but not more than 1 in 12 near the aperture. The body-chamber is at least $1\frac{1}{2}$ times its basal diameter, but the aperture is not reached. The shell is thin and smooth, except a few undulating lines on the body-chamber. The septa are direct, and distant about $\frac{1}{5}$ the diameter apart, but more remote in youth; their convexity is $\frac{1}{3}$ the diameter. The siphuncle is minute and central. Several specimens occur associated in the same stone. They are from Lower Ludlow rock, Ludlow.

General Description.—The majority of specimens referred to this species have unequal diameters, but this is in some degree due to pressure, as others are nearly circular or subquadrate. In some, from Lower Silurian beds, there is a depression along one side, which makes the section somewhat cordate, like *O. semipartitum.* In other examples of the same age there is a slight curvature observable. The measured rate of increase lies between 1 in 7 and 1 in 9, but is exceptionally less. The longest body-chamber seen is $1\frac{3}{4}$ inches, which is twice the corresponding basal diameter, and yet no line of aperture is reached. The shell in the Lower Silurian examples is thick. Most appear smooth, but several show undulating lines of growth. The septa are mostly direct, but most of the older group show a slight obliquity, amounting to 3° at most; they are distant from $\frac{1}{4}$ to $\frac{1}{5}$ the diameter, and have a convexity of $\frac{1}{3}$ to $\frac{1}{4}$ the same. One example from Kildare shows that form of normal line which is produced by the tube-like depression on the inner surface of the septal chambers. The siphuncle is minute and central. The greatest diameter seen is 10 lines, and the greatest length 4 inches. The members of this species appear to have lived in groups, as indicated by Sowerby's name, as several are often found in one slab.

Relations.—There appears to be scarcely sufficient reason for separating the Lower from the Upper Silurian examples, although the former alone exhibit the curvature, the thickness of shell, and slight obliquity of septa noted above. The central siphuncle separates them from the *O. subgregarium* of M'Coy. Salter apparently considered the Lower Silurian forms as identical with his *O. audax*, but, as

noted under that species, the flatness and greater closeness of the septa, as well as other differences, easily distinguished them. They may, however, belong to *O. pictum.* Portlock referred the same to *O. cylindraceum* and *O. inæquiseptum* of the Carboniferous rocks, but the former has not such close septa, and shows peculiarities in youth, and the latter has a more rapid rate of increase. The close septa separate the species from *O. regulare* and *O. speciosum*, to which I think some Irish specimens have been referred. It is very probable that the specimens quoted as *O. conicum* (Hisinger, but not Sowerby) belong here. I can find no feature which distinguishes this from *O. novellum*, as figured and described by Barrande.

Distribution.—In the Bala Series of Kildare (11), of Bala (1), of Marshbrook (1), of Horderley (2), and Barking Dent (1); in the Lower Silurian of Egool (1), and Desertcreat? (1); in the Lower Llandovery of Blaen-y-cwm (1), and near Cheny Longville (1); in the Upper Llandovery of Tortworth (1); in the Wenlock Series of Usk (1) and Montgomery (1); in the Lower Ludlow of Ludlow (4) and of Presteign (3).

It is also recorded by Portlock from the Lower Silurian of Tyrone; by Kelly from the same horizon at Tullyconnor, Tonlegee, &c.; by Brown and Henderson from the Upper Silurians of the Pentlands, and by Strickland from Upper Ludlow, Hagley.

ORTHOCERAS PRIMÆVUM, Forbes, Pl. XVII. fig. 4.

1845. CRISEIS PRIMÆVA, Forbes, 'Quart. Journ. Geol. Soc.' vol. i. p. 146.
1846. „ „ Sharpe, 'Quart. Journ. Geol. Soc.' vol. ii. pl. 13, fig. 2.
1852. ORTHOCERAS PRIMÆVUM, M'Coy, 'Pal. Foss.' p. 316.
1852. „ „ Salter, Appendix A to M'Coy's 'Pal. Foss.' p. viii.
1857. „ „ Salter in Murchison's 'Siluria,' Foss. gr. 62, fig. 4.
1873. „ „ Salter, 'Camb. and Silurian Foss.' pp. 97, 159.
Syn. 1846. CRISEIS VENTRICOSA, Sharpe, loc. cit., pl. 13, fig. 3.
1852. ORTHOCERAS VENTRICOSUM, M'Coy, 'Pal. Foss.' p. 318.
1852. „ „ Salter in App. A to 'Pal. Foss.' p. vii.
1873. „ „ Salter, 'Camb. and Sil. Foss.' pp. 98, 159.
Query 1843. ORTHOCERAS REGULARE, Portlock (in part), 'Geol. Rep.' p. 376.
1852. „ TORQUATUM, Salter, App. A to 'Pal. Foss.' p. vii.
1873. „ „ Salter, 'Camb. and Sil. Foss.' p. 187.

Type.—This is probably an example in the Woodwardian Museum referred to as b. 544 in Salter's Catalogue. It is a flattened specimen, giving no data except as to its rate of increase. This is 1 in 11 in the flattened impression. No signs of any ornaments are visible, and there are longitudinal cracks due entirely to breaking. The specimen commences at $\frac{5}{6}$ inch diameter, and tapers nearly to a point in $7\frac{1}{2}$ inches. It is from the Denbigh Flags.

General Description.—These flattened impressions on shale are very common, and have undoubtedly been proved to belong to *Orthocerata* by the discovery

not only of their septa, which might approximate them to the genus *Hyolithes* of Eichwald, but also of their siphuncle. It is, however, difficult to be certain of the original form of *Orthoceras* that produced them, and it is rather from want of means of separation than from positive proof of identity that the details derived from uncrushed examples are placed to the credit of this species. One section is seen elliptic, with diameters in the ratio of 6 to 5. The apparent rate of increase depends very much upon the amount of compression, and the direction of exposure on the surface. As actually measured, it varies between 1 in 7 and 1 in 9, but there are exceptions on either side, the least being 1 in 18 and the greatest 1 in 5. Those with more rapid increase have been called *O. ventricosum*, but no distinction or satisfactory line can be drawn, and they are not of more interest or abundance than those with a less rapid increase than the average. The body-chamber was probably very long, though septa are rarely seen; the longest actually proved is three times its basal diameter. The aperture was prolonged towards the back and front into tongues, of which one is longer than the other, and between these is a deep lobe on the sides. The surface of the shell is rarely preserved, and thus it would appear unornamented, but in several examples there are oblique transverse striæ or sharpish lines of growth most conspicuous on the body-chamber. The shell was probably very thin, as it is so constantly broken down. The septa are oblique, only rarely appearing direct, the obliquity being slight and in the same direction as the lines of growth. They are distant $\frac{1}{2}$ to $\frac{2}{3}$ the diameter, and their convexity is small. On one example there is a longitudinal depression in each chamber, deepening behind at each septum, and representing the inner lobe. The siphuncle is minute and central. The greatest diameter seen in flattened examples is 10 lines, and the longest shell is 9 inches incomplete.

ORTHOCERAS PRIMÆVUM, var. ANTIQUIOR.

The above description is taken entirely from Upper Silurian forms, but there are examples in the Lower Silurian which can at most be indicated as a variety in the absence of better material. These show the same differences in the rate of increase depending on the compression, those actually observed showing a rate between 1 in 7 and 1 in 14. The aperture has not been seen of the same shape as in the typical form, but as a sloping convex curve on the side: this may be due to immaturity. No transverse lines have been observed, but at the smaller end some lines of growth and indications of longitudinal foldings, not due to compression. In septal characters there is no difference.

Relations.—Some of the fragments referred by Portlock to *O. regulare* appear to belong to the Lower Silurian variety of this. The characters are still too obscure for certain comparison with any of Barrande's better known forms. The two nearest British forms are *O. tenuicinctum*, whose riblets are regular ornaments,

and young forms of *O. ludense*, which have direct septa. The specimen named by Salter *O. torquatum* is a rubbishy surface fragment, showing transverse striæ, 5 per line on the average, and tending to imbricate upwards, which may belong to this or some other species, but is in fact utterly indeterminable.

Distribution.—The typical form occurs in the Wenlock Shale of Denbighshire (1), Flintshire (1), Llangynyw (1), Nantglyn (1), Llansannan (1), and Builth Bridge (7); in the Denbighshire Flags, Cefnddu (7), and Corwen (2); in the Coniston Grit, Helmknot (1), and in the Coniston Flags, Horton (1); in the Lower Ludlow of Ludlow (1) and of Ledbury (1), and in the Upper Ludlow of Ledbury (1) and Benson Knot? (1); in the Upper Silurian of Kerry (7), Tipperary (1), and Galway (1).

The var. *antiquior* occurs in the Lower Silurian at Kilnacreagh, Clare (1), Desertcreat (9), and Fermanagh (5).

The species, as *O. primævum*, is also recorded by Salter from the Upper Llandovery of Nantglyn and Craig Hir, and from Coniston Flags, Kirby Lonsdale, and the Grits at High Hollins; also by Baily, from the Bala Limestone of the Chair of Kildare, and from the Lower Silurian, Portraine. As *O. ventricosum* it has also been recorded by Davies from the Bala Beds of Bala and Corwen, and by Salter from the Wenlock Shale, Bron Einion.

ORTHOCERAS SUBCONICUM, D'Orbigny, Pl. XII. fig. 9.

1839. ORTHOCERAS CONICUM, Sowerby in Murchison's 'Silurian Syst.'
1847. „ SUBCONICUM, D'Orbigny, 'Prodrome de Paléontologie,' vol. i. p. 2.

Not 1837. ORTHOCERAS CONICUM, Hisinger, 'Lethæa Suecica,' pl. 9, fig. 5.

Type.—The section is not known, but the part preserved has a rate of increase of 2 in 9. There appear to have been no external ornaments. The whole specimen is septate, the chamber being $\frac{1}{8}$ of the diameter apart, and having a convexity of about $\frac{1}{4}$ the same. The siphuncular apparatus occupies altogether about $\frac{1}{2}$ the diameter, and is formed by many deposits on its membranes, and on the septa. The latter rapidly decrease before reaching the former. The inner tube of the siphuncle is contracted into a cruciform shape, and the outer coat was covered by irregular deposits. The diameter is $1\frac{1}{6}$ inches, and the length $1\frac{2}{3}$ inches. From the Upper Llandovery of Tortworth. In the Museum of the Geological Society.

General Description.—The section appears to be not far from circular. The rate of increase is essentially great, at least 1 in 5. No body-chamber has been seen connected with the peculiar siphuncle of this species, but there are some specimens having about this rate of increase coming from lower rocks which may belong to it: these have signs of a constriction below the aperture. The septa vary in distance with age, being $\frac{1}{6}$ of the diameter when young, and increasing in closeness

up to $\frac{1}{10}$ when larger. The siphuncle is always central in the sections seen, and one shows it nearly central on the septal surface. The inner and outer coats of the siphuncle are always separated by deposits on their surface, and there are similar deposits in the septa; the outer coat had folds on its surface; the whole occupies from $\frac{1}{3}$ to $\frac{1}{2}$ the diameter. The greatest diameter seen is $1\frac{5}{6}$ inches.

Relations.—The peculiar character of the siphuncle combined with the rapid increase are the distinguishing features of this species. In *O. cochleatum* the tapering is not so rapid.

Distribution.—In the Upper Llandovery of Tortworth (1) and Marloes Bay (1); in the Wenlock Shale of Builth (1), and near Ludlow (1); in the Upper Ludlow of Usk (3). Possibly also specimens from the Lower Llandovery of Blaen-y-cwm belong to this.

Orthoceras circulare, Sowerby.

1814. Orthoceras circulare, Sowerby, 'Min. Con.' pl. 60, figs. 6, 7.

Type.—I have not seen among Sowerby's fossils any which corresponds to this. His figure shows the section to be elliptic, with the diameters in the ratio of 15 to 14. The rate of increase of the longer diameter is 1 in 6. The whole is a septate cast, the septa very slightly oblique, and distant $\frac{1}{7}$ the long diameter; the siphuncle is $\frac{1}{4}$ along the greater diameter. From the Upper Silurian, Dudley.

General Description.—One example seen may perhaps represent this. It has a nearly circular section, and its rate of increase is 1 in 5. It possibly had some longitudinal ornaments. The septa are undulating and distant $\frac{1}{7}$ the diameter. The siphuncle is situated $\frac{1}{5}$ of the diameter from the side, and appears to have globular elements. The greatest diameter is 8 lines, and the length 1 inch.

Relations.—This is an exceedingly doubtful species. It differs from *O. conicum*, if its siphuncle is truly complicated, in the very excentric position of that organ. It differs from *O. cochleatum* in its rapid increase and closer septa.

Distribution.—In the Upper Llandovery, Bogmine. Sowerby's was from Dudley.

Orthoceras truncatum, Barrande, Pl. XIV. fig. 8.

1868. Orthoceras truncatum, Barrande, 'Syst. Silur. de Bohême,' pl. 341–343, p. 556.

Type.—The section is elliptic, the diameters being in the ratio of 5 to 4. The rate of increase is very slow. The body-chamber decreases in size, and the aperture is oblique and undulating. The shell in most is smooth. The septa are nearly direct, and distant about $\frac{1}{3}$ the diameter. Their convexity is very great, but diminishes towards the body-chamber. The several chambers are successively cut off, and a layer of shell is deposited on the truncated end with various markings

upon it. The septa are seen in the figures to pass imperceptibly into the sides of the shell. The siphuncle is small and situated excentrically on the longer diameter. The diameter of these shells varies from $\frac{1}{8}$ inch to $3\frac{1}{4}$ inches, and the greatest length is 6 inches. They occur in a "colony," and in the beds E_1 and E_2.

General Description.—The presence of this remarkable species in England is indicated chiefly by a fragment in the Museum of Practical Geology. The diameters are in the ratio of 16 to 15, and the rate of increase is small. The septa are slightly oblique, and show very clearly the peculiar feature of being continuous with the sides. The convexity of their surface is about $\frac{1}{3}$ the diameter. The siphuncle is on the long diameter about $\frac{2}{5}$ its length from the side. The shell appears to be quite smooth. This has a diameter of $1\frac{1}{3}$ inches. Besides this are some broken-off septal chambers, presumably due, like those of *O. imbricatum*, to natural truncation, whose surface runs imperceptibly into the side. With these may possibly be associated some smaller specimens with very bulbous septa, whose distance is almost $\frac{1}{3}$ the diameter, and siphuncle as in the type.

Relations.—The peculiar feature of this species is most nearly approached by *O. Etheridgii*, which, however, is well marked off from it. The species figured by Barrande as *O. Thompsoni* has almost confluent septa, but its rate of increase is much greater.

Distribution.—In the Woolhope Limestone, Littlehope (1); in the Coldwell Flags (4). The smaller specimens are from Garcoed, Usk (3), and the Pentland Hills (2).

ORTHOCERAS EXCENTRICUM, Sowerby, Pl. XII. figs. 2, *2a*, 3.

1838. ORTHOCERAS EXCENTRICUM, Sowerby in Murchison's 'Silurian Syst.' t. 13, fig. 16, p. 631.

Type.—The section is slightly quadrate, but has equal axes; the rate of increase is 1 in 5. The whole is septate, and where the shell is partly preserved are seen slightly marked longitudinal furrows, less than $\frac{1}{8}$ inch apart, leaving convexities between: these, however, are not true ornaments, but merely representatives of multiple normal lines as seen in *O. ludense* and others. The septa are a little oblique, and have a very slight convexity, $\frac{1}{8}$ of their diameter; their distance is $\frac{1}{7}$ of the same. The siphuncle is $\frac{4}{9}$ across the diameter towards the side to which the septa slope back, and is itself $\frac{1}{9}$ of the same. Length, $2\frac{3}{8}$ inches; greatest diameter, $1\frac{1}{4}$ inches. From the Wenlock Shale, Radnor. In the Museum of the Geological Society.

General Description.—Other examples confirm most of the characters of the type—namely, the rate of increase, and the extreme flatness of the septa. No signs of ornament are seen in any. The septa are slightly undulating, but their distance is very constant. The siphuncle may have a position as far from the centre as $\frac{1}{8}$ of the whole diameter.

Relations.—The general shape is nearest to *O. gregarium*, but no other species match it in the flatness of the septa.

Distribution.—In the Wenlock Shale of Radnor (1), of Clytha, Usk (1), and of Gorstley (1 ?); and in the Upper Ludlow of Ludlow (1).

It is also recorded by Sowerby from the Lower Ludlow of Radnor; by Phillips from Woolhope, and by Brown and Henderson from the Upper Silurian (bed D) of the Pentlands.

ORTHOCERAS IMBRICATUM, Wahlenberg, Pl. XIV. figs. 1, 1*a*, 3, 3*a*, 4, 4*a*, 5, 6.

1821. ORTHOCERAS IMBRICATUM, Wahlenberg, 'Nov. Act. Upsala,' vol. viii. p. 89.
1827. " " Hisinger, 'Lethæa Suecica,' tab. 9, fig. 9, p. 89.
1870. " " Barrande, 'Syst. Sil. de Bohême,' pl. 440.
Syn. 1848. ORTHOCERAS MARLOENSE, Phillips, 'Mem. Geol. Surv.' vol. ii. pt. 1, pl. 13, fig. 1.

Not? 1839. ORTHOCERAS IMBRICATUM, Sowerby in Murchison's 'Sil. Syst.' pl. 9, fig. 2, p. 620.
1852. " " M'Coy, 'Pal. Foss.' p. 315.
1873. " " Salter, 'Cambrian and Sil. Fossils,' p. 187.

Type.—Wahlenberg's short description merely states that the type consists of imbricating sheaths, which are very convex, and not more than a line apart; and the siphuncle is very fine and filiform, and is central. The figure given by Hisinger to represent Wahlenberg's shell appears to have misled some who had not referred to the latter author, to suppose the siphuncle was nearly lateral. This figure, however, may nevertheless be taken to also represent the type, especially as its inconsistencies with the description admit of explanation. The section is probably not circular; the rate of increase is 1 in 9. The septa are moderately convex, and have an obliquity, according to the figure, of more than 15°. The siphuncle is too large to be called filiform, and is not quite in the centre. The greatest diameter is $1\frac{1}{4}$ inches, and the greatest length, all septate, is $3\frac{1}{4}$ inches. From the Upper Silurian of Gothland.

General Description.—The British specimens that are fairly referable to this species show considerable variation in many points. The section in some is nearly circular, with a tendency to being quadrate; but usually it is more or less elliptic in varying proportions, possibly owing to compression. The rate of increase of septal portions is between 1 in 7 and 1 in 9; but in the largest examples it is 1 in 12 or 13, and in one body-chamber, otherwise inseparable, only 1 in 15 (fig. 1). This body-chamber has a length of $4\frac{1}{2}$ inches, which is $2\frac{1}{2}$ times its basal diameter. There are no constrictions below the aperture, which is not well preserved. There are no ornaments beyond transverse almost invisible lines of growth in the under shell, so that it looks perfectly smooth (fig. 1*a*). The convexity of the septa is about two chambers, or $\frac{2}{7}$ to $\frac{1}{4}$ the diameter, the distance varying from $\frac{1}{7}$ to $\frac{1}{9}$ of the same, and the last is sometimes of half-size. The sutures are more or less oblique, and so

appear to undulate, but not much more than 7°. The siphuncle is moderate in size, and would scarcely be called filiform; in most it is central; but it is impossible to separate those in which it gradually gets further and further along the greater diameter, till it is only $\frac{3}{10}$ from the sides. These positions are derived from separate septal surfaces, which from their other characters are presumed to belong to the same species.

These remarkable septal surfaces have long been known, and have been regarded as belonging to *O. bullatum*. Their obliquity cannot be seen, and their narrowness would agree with the last named, but they show no signs of striæ on the sides; and in one example of *O. imbricatum* they are seen to be the models of the concave side of the septum, which in this instance shows the vascular impressions (fig. 3*a*). The thickness indicated by these casts is about $\frac{1}{8}$ their longer diameter, and the sides show a peculiar folding of the shell, which is seen also on the sides of complete examples, as, for instance, on that figured by Phillips as *O. marloense*. The great abundance of these casts, and their non-association in groups, show that the chambers of the shell fell off during the life of the animal, while the actual substance has been dissolved in the porous mudstone in which they occur, leaving only a model of the inside. The shape is usually elliptic, but sometimes rather quadrate; from the neighbourhood of the siphuncle, which is most commonly central, but often approaches one side on the longer diameter, there pass out a number of irregular lines like vascular impressions, which bifurcate as they approach the circumference, and finally end in a close fringe of capillaries round the edge. In addition to these there is a band passing from the siphuncle to some point in the side, not always to either end of the diameter, but varying in its position; this is elevated on the cast, indicating a depression on the shell itself. It seems to have a tendency to draw the siphuncle after it, for the latter is always nearer the side to which this goes. These structures are probably not peculiar to the present species, since the same may be traced on the concave side of the septum of a living *Nautilus*, but they are seen in this case, owing to the habit of truncation. The impressions are no doubt produced by the veins of the mantle, and the band by the failure of its two sides to meet in wrapping round the siphuncle.

Relations.—Some confusion has arisen with regard to this species on account of its having been figured with an excentric siphuncle, but originally described as having a central one. From the proved variability of the position of this organ, both these indications are correct; but in no case is the siphuncle bulbous. Those therefore which were figured by Barrande (pl. 228) could not belong to it. The specimen figured by Sowerby in the 'Silurian System,' though similar to this species in its approximate, oblique, and undulating septa, agrees better in the rate of increase with *O. perversum*, which is differentiated from the present not only in this respect, but by the position of its siphuncle and the convexity of the septa. The

specimen described by M'Coy follows Sowerby's. As to *O. marloense* of Phillips, I can find no justification for its establishment. The curvature shown is due solely to the dislocation of the upper part, the lower two-thirds having absolutely straight sides. Phillips says it differs also from *O. imbricatum* in having closer and more oblique septa. A comparison of the figures, however, and of Phillips's type, shows that the latter has, if anything, more remote and less oblique septa. There is very little difference between this and *O. Morrisi* of Barrande.

Distribution.—The shell occurs in the Wenlock Shale of Middleton (1), Marloes Bay (Phillips's specimen), Dudley (4), and Coldwell (1); in the Wenlock Limestone of Dudley (1); in the Lower Ludlow, Ledbury (1); in the Upper Ludlow of Ludlow (1) and Treverne Hills (1); in the Tilestones of Storm Hill (1); also in Upper Silurian Beds of Ferriter's Cove (1). Septal surfaces are found only in the Upper Ludlow, or in rocks of undefined Upper Silurian age. They are abundant at Ludlow (16), and in the Pentland Hills (11), and occur also at Mortimer's Cross (1), Wenlock (2), Stoke Edith (1), Bishop's Castle (2), Presteign (3), Aymestry (1), Treverne Hills (2), and Usk (2). As, however, it has been seen that a ribbed species, *O. kendalense*, also found in the Upper Ludlow, shows similar veined septal surfaces, some of the examples referred to the present species may belong to the latter.

Fossils by this name are also recorded by Phillips from Llandeilo, Woolhope, and Abberley; by Griffiths, from Egool, and in the Catalogue of Western Scottish Fossils, from Ardmillan Braes; and under the name of *O. marloense*, by Salter, from the Upper Ludlow, Coalbrookdale.

ORTHOCERAS PERVERSUM, Blake, Pl. XVI. figs. 1, 2.

Syn.?	1839.	ORTHOCERAS IMBRICATUM,		Sowerby in Murchison's 'Sil. Syst.' pl. 9, fig. 2, p. 620.
	1852.	„	„	M'Coy, 'Pal. Foss.' p. 315.
	1873.	„	„	Salter, 'Camb. and Sil. Fossils,' p. 187.

Type.—Section elliptic, the diameters in the ratio of 7 to 6; rate of increase of the long diameter 1 in 21 in the septate portion, reducing to 1 in 36 in the body-chamber. This is $3\frac{1}{2}$ inches long, which is more than $2\frac{1}{2}$ times its basal diameter; about 1 inch from the base is a broad and shallow thickening of the shell, $\frac{2}{3}$ inch in breadth. The aperture is simple. The shell exfoliates in two layers, the outer one being thinner and lighter in colour, and having feeble undulations of growth in the body-chamber. The septa are irregularly undulating, and distant $\frac{1}{7}$ the diameter. Their convexity is equal to two chambers or $\frac{2}{7}$ the diameter. The siphuncle is of moderate size and unsymmetrically situated, $\frac{5}{11}$ along the greater diameter and $\frac{3}{7}$ along the smaller. The septa are lowest opposite the siphuncle. The greatest diameter is $1\frac{1}{2}$ inches, and the length is 9 inches. From the Upper Ludlow, Ludlow. In the Museum of Owens College, Manchester.

General Description.—Another example with an unsymmetrical siphuncle is the specimen referred to by M'Coy and Salter; this is more or less contorted, and the peculiarity might be thought due to that circumstance. Those referred to this species have elliptic sections, and the rate of increase is between 1 in 18 and 1 in 36 in the body-chamber. The latter shows a length $2\frac{2}{3}$ its basal diameter. The septa have a varying obliquity from 5° to 15° and some amount of undulation, and are distant $\frac{1}{7}$ to $\frac{1}{10}$ the longer diameter, the later ones being closer than the earlier. Their convexity is considerable, and is greatest at the siphuncle. This is not seen in the other examples, which agree in other respects. If Sowerby's figured specimen, called *O. imbricatum,* is rightly referred here, the aperture was oblique in a contrary direction to the septa, and was bounded by well-marked lines of growth. The type is the largest example known.

Relations.—Regarding the unsymmetrical siphuncle seen in three specimens as not a mere individual peculiarity, we may separate the present species from *O. imbricatum* by this feature, but, in addition, its rate of increase is much less rapid, and the convexity of the septa is greater and their undulations more irregular. It is on these latter accounts that Sowerby's specimen is referred to this species rather than to the one he names. There are four species figured by Barrande with unsymmetrical siphuncles, but they do not show the close septa, &c., of the present. One example also, which I refer to *O. ludense,* shows the same character (see Pl. X. fig. 5), but the amount of double excentricity is much less, and I regard it only as an individual peculiarity, very likely brought about by distortion.

Distribution.—In the Wenlock Limestone (?) of Dudley (1); in the Lower Ludlow of Ludlow (2); in the Upper Ludlow of Ludlow (1), of Benson Knot (1), and of Kirby Moor (1) and Kendal (1).

Orthoceras ludense, Sowerby, Pl. X. figs. 1, 3, 4, 5, 7.

1838. Orthoceras ludense, Sowerby in Murchison's 'Silurian Syst.' tab. 9, fig. 1.
1852. ,, ,, M'Coy, 'Palæozoic Fossils,' p. 315.
1857. ,, ,, Salter in Murchison's 'Siluria,' Foss. gr. 62, fig. 2.
1873. ,, ,, Salter, 'Camb. and Sil. Foss.' p. 158.
Syn. 1857. Orthoceras columnare, Boll, 'Archiv für Mecklenb.' xi. pl. 1, fig. 3, p. 16.
1866. ,, temperans, Barrande, 'Syst. Silur. de Bohême,' pl. 230, 382, 451, p. 658.
1870. ,, Dahli, Barrande, loc. cit., pl. 440.

Type.—The section is circular, and the rate of increase, where the shell is uncompressed, is 1 in 12. The whole is septate. The septa are direct, and have no undulation. They are distant $\frac{2}{7}$ the diameter, and have a convexity of the same amount. The siphuncle has a diameter equal to half the septal interval, and is situated $\frac{7}{16}$ along the diameter. The diameter is nearly 2 inches. The second

example referred to the same species shows an aperture with well-marked folds of growth at a diameter of $3\frac{1}{4}$ inches. From the Lower Ludlow of Ludlow. In the Museum of the Geological Society.

General Description.—The section is properly circular, but is often met with elliptic, which may be due either to compression or to individual variety. The rate of increase in the septate portion lies usually between 1 in 9 and 1 in 12, thence decreasing to almost nothing in the body-chamber. The body-chamber (fig. 4) attains a length of no less than 7 inches, with a basal diameter of less than 3 inches when compressed. The increase in these large examples is entirely checked, and contraction takes its place. The aperture has an undulating outline; the lines of growth bending forward $\frac{1}{7}$ the diameter on one side, and backward on the other. The surface of the shell is smooth except for these lines of growth, which are only conspicuous on the larger examples. The septa in the normal form are direct, without any undulation; but in some examples, not otherwise to be separated, there is some amount of waving, in which case the specimens may be distinguished as var. *undulata*. There is no real obliquity, and the convexity is from $\frac{1}{3}$ to $\frac{1}{4}$ the diameter when not increased by compression. They are distant normally $\frac{2}{7}$ the diameter, but this is not quite constant; in mid-age they are rather closer, in the young wider apart, and the last two or three may be of half the depth. The siphuncle is described by Sowerby as central, though it is not quite so in the type. In many examples it is accurately in the centre; but it certainly changes position without there being any other difference in the shell. When the diameters are unequal, it is found on the shorter, the extreme case noticed being nearly $\frac{1}{3}$ only from the side; in one example it is doubly unsymmetrical (fig. 5). Its diameter is $\frac{1}{7}$ of the whole diameter, being very slightly dilated between the septa; at its junction with which are usually some annular deposits (fig. 3). In some sections, lines are observed to pass from one septum to the next; but these are not calcareous, and are merely the relics of a membranous siphuncle. The shell in some examples has a thickness of 1 line, and on the cast in one case are seen a large number of longitudinal risings which are not ornaments, being invisible outside, but represent a kind of normal line (fig. 1). The greatest diameter actually observed is a little over 3 inches. Examples of more than 2 feet in length are in the Ludlow Museum. The longest actually studied is $15\frac{1}{2}$ inches (fig. 1), in which the body-chamber had not commenced; other body-chambers of less diameter reach $7\frac{1}{2}$ inches in length, and as the smaller diameter in this example is $1\frac{1}{2}$ inches we must allow at least $10\frac{1}{2}$ inches for the smaller end. The total length of this example would therefore be more than 2 feet 9 inches. The existence of still larger ones may be safely asserted. The largest known septal surface, $3\frac{1}{3}$ inches in diameter, should correspond by comparison to a body-chamber at least 1 foot 1 inch long, if it be the last chamber. Another example reduces the diameter from 3 to 2

inches in $15\frac{1}{2}$ inches; a third reduces it to 17 lines in $13\frac{1}{2}$ inches; a fourth reduces it to 13 lines in $5\frac{1}{4}$ inches; a fifth tapers from $11\frac{1}{2}$ lines to 9 lines in 17 lines, which would reduce from 13 lines to 8 lines in $2\frac{3}{4}$ inches; a sixth reduces it from 8 to $4\frac{1}{2}$ in $3\frac{1}{2}$ inches; and a seventh $3\frac{1}{4}$ to $1\frac{1}{2}$ in 19, which will give about 2 inches for the last portion. Adding these, we should have a shell whose length is 4 ft. $7\frac{1}{2}$ inches! Small specimens are very likely to be confounded with other species in the absence of connecting forms. They are most probably to be recognised in those whose septa are at least $\frac{1}{3}$ the diameter apart, and which have strong shells and a central siphuncle.

Relations.—M'Coy thought he had identified this with *O. distans* when he proved that its siphuncle was not always central; but in the latter species the septa are much further apart than they would be at the like diameter in our present shell. On the other hand, such species as *O. gregarium* (from which it cannot well be distinguished when the shell is preserved) and *O. subgregarium*, which are of small size, differ by having the septa closer, while in *O. politum* and *O. primævum* they are more remote. So common and wide-spread a species as this is not likely to be confined to England; and though Barrande makes no attempt at comparison, there is nothing of importance to distinguish it from his *O. temperans*, which, though figured with an excentric siphuncle, is stated also to have a central one, or from *O. columnare* of Boll, with which Barrande has subsequently united his *O. Dahli.*

Distribution.—In the Upper Llandovery of Bogmine (2); in the Wenlock Shale of Usk (2); in the Wenlock Limestone of Dudley (4), Malvern (2), and Tortworth (1); in the Lower Ludlow of Ludlow (9), Leintwardine (4), Woolhope (1), and Ledbury (4); in the Aymestry Limestone of Usk (2); in the Upper Ludlow of Usk (1), Ludlow (3), Ledbury (1), and Kendal (1); also in the Coniston Grits of Middleton (1), and in the Upper Silurian of the Pentland Hills (3) and of Galway (1).

It is also recorded by Prof. Hughes from the Coniston Flags, and by Salter from the Coniston Grits of Helm Knot, and from the Lower Ludlow of Coalbrookdale. In Bohemia and in Sweden it is an Upper Silurian species.

ORTHOCERAS DISTANS, Sowerby, Pl. XV. figs. 1, 2.

1838. ORTHOCERAS DISTANS, Sowerby in Murchison's 'Silurian Syst.' pl. 8, fig. 17, p. 619.
Syn. 1866. ORTHOCERAS MIGRANS, Barrande, 'Syst. Sil. de Bohême,' pl. 212, 309, 348, &c., p. 643.
Query 1866. ORTHOCERAS THOMSONI, Barrande, loc. cit., pl. 218.

Not 1873. ORTHOCERAS DISTANS, Salter, 'Camb. and Sil. Foss.' p. 159.

Type.—The section is elliptic, with the long diameter in the ratio of 14 to 13. The fragment is too short to determine the rate of increase accurately, but it is

very small. The surface is not preserved. The septa are direct and have a convexity of about $\frac{1}{2}$ the diameter. Their distance is about $\frac{5}{6}$ the long diameter. The siphuncle has a diameter of $\frac{1}{7}$ the same line and lies $\frac{3}{5}$ across the long diameter, which is $1\frac{1}{4}$ inches. From the Lower Ludlow of Aymestry. In the Museum of the Geological Society.

General Description.—Examples referred to this species, on account of the remoteness of their septa, show sufficient variation in that element and in the apparent rate of increase of the shell, to render it possible that better specimens would prove the existence of more than one species. The section is elliptic, and the difference of diameters becomes more marked by compression. The rate of increase in flattened or compressed examples is 1 in 4 and 1 in 8 respectively; and in a small one, 1 in 7. The body-chamber is $3\frac{1}{2}$ times its flattened basal diameter; it remains uniform to the aperture, which is simple, but imperfectly preserved. In the young shell there were some transverse striæ, not observed in larger specimens. The septa are direct, and have a convexity of less than $\frac{1}{3}$ the diameter. Their distance is always greater than $\frac{1}{2}$ the same, but in none are they seen quite so remote as in the type. The siphuncle is excentric on the long diameter about $\frac{3}{5}$ across, but also in one example $\frac{7}{16}$ across the short one,—an irregularity probably due to compression. Its structure was either more or less bulbous, or there was a deposit around the neck of the septa. Its size is from $\frac{1}{6}$ to $\frac{1}{7}$ the diameter. The greatest diameter is $1\frac{2}{3}$ inches, and the greatest length seen is 8 inches.

Relations.—Now that this species is better known, it cannot be thought to have any close relations to *O. ludense*, as supposed by M'Coy. In the specimen referred to by Salter, as showing longitudinal lines, the supposed septal lines are cracks. Several of Barrande's species may differ from this in details on which our material affords no information, but I think *O. migrans* will in any case be among its synonyms. The *Orthoceras Thomsoni* of Barrande, figured as having come from the Silurian of Scotland, but from an unknown part of it, is too imperfect a specimen, being worn away on the outside, to make any certain determination of; but in spite of its apparently more central siphuncle, it very probably represents the present species. This differs from *O. vagans* in its more regularly spaced septa and less central siphuncle.

Distribution.—In the Wenlock Shale, Rebecca Hill (1); in the Wenlock Limestone, Malvern (1); in the Lower Ludlow of Ledbury (1) and of Aymestry (3); and in the Upper Ludlow of Aymestry (1).

It is also recorded by Garner from the Lower Ludlow of Hay Head.

ORTHOCERAS BACULIFORME, Salter, Plate XV. fig. 3.

1852. ORTHOCERAS BACULIFORME, Salter, App. A to M'Coy's 'Pal. Foss.' pl. 1 L, fig. 27, p. vi.
1852. " " M'Coy, 'Pal. Foss.' p. 315.
1873. " " Salter, 'Camb. and Silurian Foss.' p. 187.

Type.—The specimen figured by Salter is a fragment only of a shell of which another portion is preserved in the Woodwardian Museum, which was, no doubt, obtained at the same time. When these are placed together, as in fig. 3, they show that the supposed peculiarities of the species are due to pressure. Though the lower septal part is elliptical by compression, the body-chamber is pretty accurately circular. The rate of increase, however, is very small, not being more than 1 in 32. The body-chamber is four times as long as its basal diameter. It is covered by undulating lines of growth, which are occasionally very clearly marked, and are generally thrown into groups. No other ornaments are seen. The septa are direct and have a convexity of $\frac{1}{4}$ the diameter, and are distant a little more than $\frac{1}{4}$ the same. The siphuncle is very nearly central. The greatest diameter is 7 lines; and the length preserved, 4 inches. From the Upper Ludlow of Brigsteer. In the Woodwardian Museum.

General Description and Relations.—It is doubtful if any other example of this species is known. The chief peculiarity about it is the extremely slow rate of increase combined with its comparatively small size. The former of these features prevents our associating it with *O. gregarium;* and the latter, combined with the greater remoteness of its septa, separate it from *O. perversum.* It therefore remains distinct in spite of the change of its characters.

Distribution.—In the Upper Ludlow, Brigsteer, Westmoreland (1).

ORTHOCERAS OMISSUM, Blake, Pl. XV. figs. 9, 9*a*.

Type.—The section is elliptical, the axes being in the ratio of 5 to 4. The rate of increase in the long diameter is 1 in 20. No body-chamber or surface is seen. The septa are greatly undulating on the broad side, but are not far from direct on the whole. Their convexity is equal to their distance, which is more than $\frac{1}{4}$ the longer diameter. The siphuncle is on the short diameter $\frac{4}{11}$ across it, and has a diameter $\frac{1}{5}$ of the whole. The greatest diameter is $1\frac{1}{2}$ inches, and the length is 5 inches. From the Upper Ludlow of Benson Knot. In the Museum of Practical Geology.

General Description.—The section is always elliptical, though often rendered more so by pressure, till the ratio becomes as 3 to 2. The rate of increase varies from the same reason between 1 in 15 and 1 in 26. In one example, not however certainly of this species, the body-chamber undergoes a decrease, is 4 times its

longer basal diameter, and slightly expands at the aperture, which is somewhat oblique. The septa are always strongly undulating on the broad side. Their convexity is about equal to their distance, which is from more than $\frac{1}{4}$ to $\frac{1}{5}$ the long diameter. The siphuncle is on the short diameter from $\frac{1}{3}$ to $\frac{3}{7}$ of that line from the side. It is seen in three examples to be $\frac{1}{5}$ the diameter, and is probably bulbous. The greatest diameter seen is 2 inches; the greatest length, that of the type, 5 inches.

Relations.—This species differs from *O. baculiforme* in its siphuncle being on the short diameter, instead of being central or on the long diameter; from *O. ludense* by its undulating septa. This also distinguishes it, together with its slower rate of increase, from *O. subgregarium.* It is possible that the examples referred to *O. cochleatum* from the Tilestones belong to this, though they agree better with the other in their closeness of septa and their rate of increase.

Distribution.—Examples have hitherto been only seen from the Upper Ludlow of Benson Knot (6).

Subgenus ACTINOCERAS.

ORTHOCERAS (ACTINOCERAS) COCHLEATUM, Schlottheim, Pl. XV. figs. 7, 8.

1813. ORTHOCERATITES COCHLEATUS, Schlottheim, 'Min. Tasch.' vol. vii. p. 34.
1820. ,, ,, Schlottheim, 'Petrefactenkunde,' p. 55.
1866. ORTHOCERAS COCHLEATUM, Barrande, 'Syst. Sil. de Bohême,' pl. 233–7.
Syn. 1821. ORTHOCERAS CRASSIVENTRIS, Wahlenberg, 'Nov. Act. Soc. Sc. Upsala,' vol. viii. p. 90.
1837. ,, ,, Hisinger, 'Leth. Suecica,' pl. 10, p. 30.
1839. ORTHOCERAS NUMMULARIUM, Sowerby in Murchison's 'Silur. Syst.' pl. 13, fig. 24.
1857. ,, ,, Salter in Murchison's 'Siluria,' pl. 26, fig. 5.

Type.—Schlottheim merely describes his species as one which has swollen bulbs for its siphuncle, and which occurs in Sweden. The name, however, has been generally adopted and applied to the species described at a later date by Wahlenberg under the name *O. crassiventris.*

General Description.—The British specimens usually referred to this species consist merely of isolated siphuncles, which may of course belong to various species, but there are some at least which cannot be fairly located with any other known species than the present one, and others are placed with these for want of means of distinction. In no example is the true form of section seen. The rate of increase of the sections exposed is 1 in 10 or, at most, 1 in 8. There are no signs of any ornaments on the surface. The septa are on the whole direct, but undulate a little; their convexity is nearly $\frac{1}{2}$ the diameter, and their distance from $\frac{1}{5}$ to $\frac{1}{6}$ of the same. Sowerby's figured example of *O. nummularium* shows a distance of the septa of only $\frac{1}{8}$ the diameter, but those seen may be the last two of the series, which are often closer. The siphuncle appears to vary in position according to the preservation of

the shell; it is never seen lateral, and would seem to be really sub-central. The greatest diameter of the bulbs is from $\frac{3}{8}$ to $\frac{2}{7}$ the whole diameter. These bulbs, which constantly occur alone, and the characters of which are therefore important, are flattened spheroids lying between the septa. The transverse diameter is usually twice the longitudinal, and the aperture between them is equal to the latter; but when they are flattened, they become narrower and communicate by wider openings. That there is a double membrane seems proved by different specimens: one shows on the outside of the bulbs about 30 longitudinal bands (fig. 7), and another shows that within the bulbs there was a membrane drawn up in folds to the centre and communicating from the front to the back of the bulbs (fig. 8). The greatest length preserved is $3\frac{1}{2}$ inches, and the greatest diameter $2\frac{1}{2}$ inches.

Relations.—By universal consent the *O. crassiventris* of Wahlenberg is the same as Schlottheim's *O. cochleatum*, while, as stated above, *O. nummularium* may be merely a fragment representing the last two chambers only. More than one species may possibly be included here, but they all differ from *O. conicum* in the slower rate of increase, and from *Tretoceras bisiphonatum* by their flatter siphuncular beads.

Distribution.—In Lower Silurian rocks, Gwenfydd (2); in the Lower Llandovery, Mullock (1); in the Upper Llandovery of Llandovery (1), Bogmine (1), Marloes (1), Tortworth (1), Eastnor (3), Norbury (1), Charfield (1), and Cerrig-y-druidion (1); in the Wenlock Beds of Tortworth (1); in the Upper Ludlow of Kirby Lonsdale (2); and the Tilestones of Horeb Chapel (3).

Subgenus Endoceras.

Orthoceras (Endoceras) Brongniartii, Troost, Pl. XVII. figs. 1, 1*a*.

1837. Conotubularia Brongniartii, Troost, 'Mem. Soc. Géol. de France,' vol. iii. pl. 9, fig. 2, p. 89.
1843. Orthoceras Brongniartii, Portlock, 'Geol. Rep.' pl. 28, fig. 4, p. 368.
1857. „ „ Salter in Murchison's 'Siluria,' p. 199.

Type.—The figure given by Troost represents a large shell increasing at the rate of 2 in 13. The septa are undulating, and distant about $\frac{1}{5}$ the diameter. He states that the section is elliptical and the siphuncle lateral. It does not appear, however, that it is so lateral as to have part of its boundary coinciding with that of the shell; its diameter is almost $\frac{1}{3}$ of the whole, and it is surrounded, as indicated by the generic name, by the necks of the septa. The length is $6\frac{1}{2}$ inches, and the greatest diameter is $3\frac{1}{8}$ inches. From the Lower Silurian of Tennessee.

General Description.—The specimen figured by Portlock, and others examined, agree very closely with this description. The section is elliptic, the axes being as 9 to 7. The rate of increase of the longer diameter is 1 in 7 to 1 in 5. The body-

chamber, seen in some, is crowded with smaller *Orthocerata*, with their apices in the same direction as that of the larger shell. These are so close together that the improbability of their being accidentally enclosed is increased a hundredfold, and three examples showing the same features force on us the conclusion that the small ones are related to the large. The walls of the body-chamber seem almost to have been soft, and more or less forced out of shape by the small shells within. The septa in Portlock's example are direct, but somewhat undulating; they are distant $\frac{1}{6}$ the long diameter, and are seen to be produced below into long necks ensheathing the siphuncle, as is characteristic of *Endoceras*. Their general convexity is $\frac{2}{9}$ the long diameter. The siphuncle has a diameter $\frac{1}{3}$ of the minor axis of the shell, and its centre is situated about $\frac{2}{5}$ across the latter line. The little shells are nearly circular in section, taper at the rate of 1 in 10, have direct septa about $\frac{1}{3}$ the diameter apart, and a large but nearly central siphuncle. These characters would agree best with *O. politum*, but the large size of the siphuncle shows they may really be the young of the specimens containing them. The greatest length of the large ones is 4 inches, and the greatest diameter is 3 inches.

Relations.—I can only find one difference between our English and the American form, and that is the lateral siphuncle of the latter; in the absence of proof, however, that it is really so lateral as in *E. vertebrale* or *E. duplex*, it will be well to leave the name, adopted by so many previous authors, untouched.

Distribution.—In the Bala Beds of Desertcreat (1) and of Bala? (1);[1] and in Lower Silurian rocks of Waterford (3).

It is also recorded by Nicholson from the Green Slates of Ingleton, and by Harkness also from the Dufton Shales of Westmoreland.

ORTHOCERAS (ENDOCERAS) FESTINANS, Blake, Pl. XVII. figs. 3, 3*a*.

Type.—The section is not quite regular, and the specimen may have been therefore somewhat compressed; at present it is elliptic, having the radii in the ratio of 4 to 5. The rate of increase of the long diameter is 2 in 15. No body-chamber or ornaments are seen. The septa are slightly undulating, and are distant $\frac{1}{10}$ the diameter. They form long necks in the neighbourhood of the siphuncle, which they are seen to cross on the worn surface at a distance of one chamber towards the apex. Their convexity is about $\frac{1}{5}$ the diameter. The siphuncle is cylindrical, having a diameter of $\frac{1}{2}$ the longer diameter of the shell; it lies close against the side on the shorter diameter. The length seen is $3\frac{1}{8}$ inches, and the greatest diameter $3\frac{1}{3}$ inches.

[1] The specimen figured by Salter, 'Mem. Geol. Surv.,' vol. iii., pl. 24, fig. 6, but not named, may belong here, as it agrees so far as its characters are shown, except in its perhaps abnormal curvature. There is also some appearance in it of a large siphuncle, but this is doubtful. It agrees with no other British form.

Relations.—This species is of course closely allied to *E. duplex*, but it nevertheless seems distinct; for its rate of increase is 3 times as great, its section is naturally elliptic, and the septa are more than twice as approximate. From *E. Brongniartii* its more lateral siphuncle distinguishes it. If the "*Endoceras*" *vertebrale*, Eichwald ('Leth. Ross.' pl. 46, fig. 4), is rightly drawn, it must belong rather to the subgenus *Conoceras;* but if it be *really* an *Endoceras*, this species will be very close to it, the only difference being that our species has less distant septa.

Distribution.—In Lower Silurian Beds, Worthen, Shropshire (1). The specimen is in the British Museum.

Orthoceras (Endoceras) vaginatum, Schlottheim.

1813. Orthoceratites vaginatus, Schlottheim, 'Min. Taschenbuch,' vol. vii. p. 69.
1845. „ „ De Verneuil, 'Geology of Russia,' vol. ii. pl. 24, fig. 6.
1851. Orthoceras vaginatum, Salter, 'Quart. Journ. Geol. Soc.' vol. vii. pl. 10, fig. 7.

General Description.—I have not seen the example referred to by Salter, nor any other which might represent this species, yet his figure leaves little doubt of its really occurring at Girvan. No section is visible; but the rate of increase of the diameter exposed is about 1 in 11. There are well-marked transverse direct riblets and stronger undulations at a distance of $\frac{1}{5}$ the diameter. The septa mark the siphuncle with sheaths as in *E. duplex*, which, though in the figure they look to point forwards, are doubtless nearly direct; they are distant $\frac{1}{5}$ the mean diameter, and the siphuncle itself is $\frac{2}{7}$ of the same. The greatest length is $2\frac{2}{3}$ inches, and greatest diameter $1\frac{1}{4}$ inches.

Relations.—The transverse ribs separate this species from all other *Endocerata* that occur in British rocks; and there is nothing in this specimen that should separate it from the Russian species.

Distribution.—In the Middle Silurian of the Girvan district.

Subgenus Tretoceras.

Orthoceras (Tretoceras) bisiphonatum, Sowerby, Pl. XVI. figs. 3, 3*a*, 3*b*, 4.

1839. Orthoceras bisiphonatum, Sowerby in Murchison's 'Silurian Syst.' pl. 21, fig. 23.
1858. Tretoceras bisiphonatum, Salter, 'Quart. Journ. Geol. Soc.' vol. xiv. pl. 12, p. 177.
1874. „ „ Barrande, 'Syst. Silur. de Bohême,' vol. ii. p. 800.
Query 1868. Actinoceras baccatum, Woodward, 'Geol. Mag.' vol. v. pl. viii. p. 133.

Type.—There are two fragments associated with the piece figured by Sowerby belonging to the same specimen. The section is not actually visible, but it appears to be circular (fig. 3*a*). The rate of increase is very small. The body-chamber is prolonged backwards through the septa, preserved in a tube of $\frac{5}{8}$ in. diameter; this

prolongation appears to have had a separate sheath on the inside, as it is not marked in any way by the septa, but has upon its distal surface longitudinal lines bounded by three deeper furrows, as though they were muscular impressions. These impressions are very similar to those found in the little internal lobe of the recent *Nautilus*, to which this prolongation is possibly homologous. The septa are direct, and distant about $\frac{1}{10}$ the diameter; their convexity is $\frac{1}{4}$ of the same. They are very little affected by the lateral tube, those nearest the body-chamber bending down slightly as they embrace it, but not so much as to reach the next septum. The siphuncle is situated about $\frac{2}{5}$ across the diameter, in the same radius as the lateral tube. Its swollen diameter is 5 lines, thus reaching to within 1 line of the tube, but it contracts to half its size at the septa. Its bulbous exterior is granular. The length preserved is about 3 inches, and the greatest diameter $3\frac{1}{3}$ inches. From the Lower Llandovery rocks of Llandovery. In the Museum of the Geological Society.

General Description.—No other specimen has yet appeared showing any similar peculiar features, and therefore but little additional information can be obtained on their meaning; but as this is a large specimen, we are led to ask if smaller ones cannot be found which might develop this form of body-chamber. The form described by Woodward as *Actinoceras baccatum* appears to answer this requirement exactly. It is of somewhat, but not considerably, smaller size; its rate of increase rather greater. The number and convexity of the septa; the position, size, and above all the character, of the siphuncle—nearly spherical in both—all are consonant with the idea of its identity with the species at present under description: certainly there is nothing to distinguish them in the parts that are comparable. I have not been able to examine the original of *A. baccatum*, but a more instructive example in Dr. Grindrod's collection (fig. 4) shows the much greater thickness of the organic deposits on the septa in the earlier than in the later part of the shell: this is seen by the septa being represented by wide gaps below, but narrow ones above, and, more important, the folds of the internal siphuncular membrane dividing the cavity into four, of which there is some appearance also in fig. 3*b*.

Distribution.—In the Lower Llandovery Beds, Llandovery (1), and in the lowest Woolhope Beds, Woolhope (2).

Subgenus Conoceras.

Orthoceras (Conoceras) eoum, Blake, Pl. XVI. figs. 5, 5*a*.

Syn. 1866. Endoceras eoum, Wyatt-Edgell, 'Geol. Mag.' vol. iii. p. 161 (name only).

Type.—The section is not seen, and the rate of increase is very small; nevertheless the larger end of the specimen may be pretty satisfactorily made out. The

interior only is seen, and this shows a lateral siphuncle of $\frac{2}{7}$ the whole diameter. The septa are now oblique, probably by contortion, and are distant $\frac{1}{6}$ the diameter. On reaching the siphuncle, they bend slightly upwards towards the aperture; though the chambers here stop short, the septa are continued over the siphuncle slightly bending upwards, and along the latter is a depressed line. Thickenings of the shell in the chambers have left depressions between the septa sloping up at a greater angle than themselves. Length, 10 lines; diameter, 5 lines. From the Arenig Beds of Lord's Hill, Shelve. In the Museum of Practical Geology.

Relations.—This cannot be an *Endoceras*, as the septa certainly do not make sheaths pointing backwards, nor have we any proof that it is a *Tretoceras*. Hence, though the inclination forward of the septa is not nearly so marked as in Barrande's examples, it belongs, I think, to the above subgenus, and its special character is this very feebleness of forward inclination of the sutures.

Distribution.—Only the type is known. From the Arenig, Shelve.

Genus CYRTOCERAS.

Section Endogastrica.

CYRTOCERAS PRÆCOX, Salter, Pl. XVIII. figs. 6, 7.

1866. CYRTOCERAS PRÆCOX, Salter, 'Mem. Geol. Surv.' vol. iii. pl. 10, fig. 3.

Type.—This is a short fragment imbedded in the slate (fig. 7), in such a way that only one end of it is seen—the rest being still covered—so that the outline at the base is not that of the shell. On the apparently concave side a fragment is torn up at right angles, which being replaced would remove the appearance of concavity. For these reasons I was inclined to regard this specimen as merely a contorted *O. sericeum.* Nevertheless the septal lines have somewhat of the curvature of a *Cyrtoceras*, and part of the exterior boundary looks convex. Hence, another undoubted *Cyrtoceras* of similar age having been found, this may be admitted. The septa curve backwards towards the convex side, and are distant $\frac{1}{10}$ the diameter. The body-chamber is shorter than its basal diameter, and the aperture has a forwardly curved outline. The greatest diameter is nearly $\frac{1}{2}$ inch, and the length preserved nearly 1 inch. From the Lower Tremadoc Slates, Llanerch. In the Museum of the University College for Wales, Aberystwith.

General Description.—Another example (fig. 6) is a more satisfactory *Cyrtoceras.* No section is seen; the curvature has a mean radius of $3\frac{1}{2}$ inches. The rate of increase is about 1 in 4. Across the surface are a number of parallel folds; but whether they are folds of growth, and the deeper lines the septa, or whether they

are merely due to the tension of the material, cannot be determined: towards the smaller end are appearances which may be interpreted as a slightly bulbous external siphuncle, though this may well be doubted, all other British Lower Silurian *Cyrtocerata* having their siphuncle internal or unknown.

Relations.—These two specimens are not certainly one species—but they may be—and that is sufficient in these obscure forms.

Distribution.—In the Lower Tremadoc, Llanerch (1), and in the Upper Tremadoc, Garth (1).

CYRTOCERAS SONAX, Salter, Pl. XIX. figs. 1, 1*a*, 2, 3.

1866. CYRTOCERAS SONAX, Salter, 'Memoirs of the Geol. Survey,' vol. iii. pl. 25, fig. 1, p. 357.
Syn. 1865. CYRTOCERAS INÆQUISEPTUM, Baily, 'Explanation of Sheet 167,' &c., p. 21.
1866. „ ATRAMENTARIUM, Salter, loc. cit., pl. 25, figs. 2–4, p. 358.
1873. „ FORBESI, Bigsby, 'Thesaurus Siluricus,' p. 172.

Not CYRTOCERAS FORBESI, Barrande, 'Syst. Sil. de Bohême,' pl. 115.

Type.—The section is elliptic in the ratio of 19 to $16\frac{1}{2}$, the curvature being in the plane of the long axis. The long diameter decreases at the rate of 1 in 5, as measured along the convex edge. The mean radius of the external curvature is 6 inches. The surface has rough lines of growth, consisting of forward imbrications, which are grouped in series by growing more conspicuous here and there. These run nearly directly all round. The body-chamber is more compressed than the septate portion. The aperture is not seen. The septa have a convexity of about $\frac{1}{5}$ the long diameter, and are at a variable distance. At a long diameter of $19\frac{1}{2}$ lines they are 3 lines apart, but get closer at last. The sutures are very slightly concave, and nearly direct. The siphuncle is moderate in size, near the concave border; curved length, $5\frac{3}{4}$ inches. Greatest diameter of whorl, $2\frac{3}{4}$ inches. From the Bala Beds at Rhiwlas. In the Museum of Practical Geology.

General Description.—The differences specially dwelt upon by Salter in separating, as a distinct species from this, his *C. atramentarium*, which occurs in the same locality, are the slight curvature of the shell and of the septa, and the greater thickness of the section in the present species. These differences seem to lose their importance when we consider the two forms in the relation of young and adult. Only one other specimen than the type shows as great a proportionate thickness, and specimens which by the directness of their septa might be thought to belong to the one show the narrowness of the other. Indeed the variation is so great that it is probably largely due to compression, especially as one example shows an ovoid and not elliptic section. The rate of increase in the smaller form, called *C. atramentarium*, is 1 in 4 instead of 1 in 5, but it is very usual for this to decrease with

growth. Some also show signs of compression by their irregular shape, and one gives thus a rate of increase of 1 in 3. The mean radius of curvature in the same example is $2\frac{2}{3}$ inches; but as the mean diameter of the shell is less than half that of the type, the decrease of the radius of curvature is just proportional, as it should be if they were of the same species. Thus the greater curvature is a proof, not of difference, but of identity; and an example, probably referred to by Salter as the young of *C. sonax*, which shows very little curvature, for this reason, among others, I refer to another species. The most characteristic feature of the species under description is its direct, imbricating, strong, grouped lines of growth. In an instructive example (fig. 3) showing the decrease of curvature with age, we see in the younger part these groups slope considerably backwards, as they are said to do in *C. atramentarium*, though the examples of the latter do not show this feature well. The strength of these transverse lines is variable. The body-chamber in some seems to contract a little towards the aperture, the edge of which, on the contrary, expands. The specimen figured by Salter to show the aperture more oblique in *C. atramentarium*, may not belong to this species; its curvature is too small. The convexity of the septa is from $\frac{1}{5}$ to $\frac{1}{6}$ the long diameter, and they are distant from $\frac{1}{6}$ to $\frac{1}{9}$. The sutures are only slightly concave, and are more direct in the adult than in the young. The siphuncle is always internal, about $\frac{1}{10}$ the linear dimensions of the septum, and oval in shape. It may be bulbous. One example shows some interrupted longitudinal lines, which may be epidermids.

Relations.—*Cyrtoceras atramentarium* of Salter, described at the same time as this, cannot, as above seen, be satisfactorily separated from it. The name of *C. Forbesi* has somehow become attached to this in the Museum of Practical Geology, and has thence been transferred to the 'Thesaurus Siluricus' of Dr. Bigsby. That species, as figured by Barrande, has some superficial resemblance to this, but is completely cut off from it by having an external siphuncle. Much nearer is the *Cyrtoceras conspicuum* of the same author, which differs chiefly by its closer and more sigmoid sutures. It differs from *C. inæquiseptum*, to which an Irish specimen was referred by Baily before its establishment, in having straighter sutures and a uniformly convex aperture, though its dimensions are very similar.

Distribution.—In the Bala Beds at Rhiwlas (14), at Sholeshook (6), at Cheney Longville (1), at Helmgill (1); in the Upper Silurian, Llanfair (1); and in the Lower Silurian, Tramore, co. Waterford (1). They are mostly in the Museum of Practical Geology. The one from Cheney Longville is a pretty specimen in the Woodwardian Museum, doubtfully belonging here on account of its more regular ridges of growth. The matrix of most is the ordinary Bala ash, but some of those from Sholeshook are in a light yellow sandstone.

CYRTOCERAS MACRUM, Blake, Pl. XX. fig. 3.

Type.—Section elliptical, with diameters in the ratio of 7 to 6, the long diameter in the plane of curvature; mean radius of curvature 19 lines. The long diameter increases at the rate of 1 in 7, measured along the convexity. No surface is seen, and all is septate. The septa have a convexity of about $\frac{1}{4}$ the diameter. They are very close at $\frac{1}{6}$ the mean diameter apart. Sutures sigmoidal rather than concave, the more convex part on the inside, a little oblique, rising to the convex side. The siphuncle is not clearly seen, but it may be small and internal. From the Bala Beds, Rhiwlas, Bala. In the Museum of Practical Geology.

General Description.—This cannot be considered a satisfactorily determined species, as two very important points of its diagnosis are wanting—the surface and the true position of the siphuncle. It is, I think, distinct from *Cyrtoceras plebeium*, though closely allied. It is stouter, has less curvature, and a slower rate of increase with more sigmoid sutures. Of course, if the siphuncle be internal, the distinction is complete.

Distribution.—In the Bala Beds, Rhiwlas (1).

CYRTOCERAS REVERSUM, Blake, Pl. XXI. fig. 5.

Type.—Section doubtful, as the specimen is compressed in the shale. It appears now to be elliptic, with diameters in the ratio of 18 to 11, the long diameter being in the plane of curvature. External mean radius of curvature, $3\frac{1}{4}$ inches; hence the curve is slight. The long diameter increases at the rate of 1 in less than 3. The surface at present is smooth, but the outer layer of the shell is not seen. The whole is septate, and the septa are about $\frac{1}{7}$ the long diameter apart. The great peculiarity of the species lies in its sutures, which, instead of being concave forwards and nearer the aperture on the outside as usual, curve gently backwards, and are thus oblique and convex to the aperture. The siphuncle is not certainly seen, but seems to be internal. Length, $19\frac{1}{2}$ lines; greatest diameter, 1 inch. From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.

General Description.—The type is unique.

Relations.—The remarkable character of the sutures separates this species from all others except *C. inæquiseptum*, which is a much stouter form, and even in that the character is not so marked.

Distribution.—In the Lower Ludlow, Ledbury (1).

CYRTOCERAS INÆQUISEPTUM, Portlock, Pl. XX. figs. 5, 5*a*, 8.

1843. PHRAGMOCERAS INÆQUISEPTUM, Portlock, 'Geolog. Report,' pl. 28A, fig. 4 *a*, *b*, p. 382.
1854. CYRTOCERAS INÆQUISEPTUM, Morris, 'Catalogue of Brit. Fossils,' p. 302.
1857. „ „ Salter in Murchison's 'Siluria,' Foss. gr. 43, fig. 1.
Syn. 1843. PHRAGMOCERAS BRATERI, Portlock, loc. cit., pl. 28B, fig. 3, p. 383. (Not *P. Brateri* of Münster.)
— PHRAGMOCERAS ARCUATUM, Portlock, loc. cit., pl. 28A, fig. 5, p. 382.
— PHRAGMOCERAS (?), Portlock, loc. cit., pl. 28B, fig. 4.
— CYRTOCERAS (?), Portlock, loc. cit., pl. 28B, fig. 6.

Type.—Portlock's type of this species is a poor specimen; his *P. Brateri* is better preserved, but as that cannot be used it can only supply the description of the species, and cannot serve as the type. The figured specimen is flattened in on one side, and thus is out of shape, but the section must have been elliptical or oval, with the curvature in the plane of the longer axis. The inner side is nearly straight, but the outside has a mean radius of curvature of $2\frac{1}{4}$ inches. The rate of increase of the long diameter is about 1 in 3. No surface is seen, but the body-chamber, about 10 lines long, is terminated by an aperture with a sigmoid boundary, and parallel to this are seen at least two thickenings of the shell distant 5 and 7 lines further back. There is a slight contraction towards the aperture, but not beyond what is common in *Cyrtocerata.* The septal surface is not seen. The distance of the septa seems variable, one or two of those near the body-chamber especially being of half size; but this is not an uncommon feature in many species. The mean distance is $\frac{1}{12}$ the long diameter. The sutures are very slightly concave and a little oblique, rising highest on the concave side of the shell. The siphuncle is not properly seen, but it may be internal. Length, $2\frac{1}{4}$ in.; greatest breadth, $1\frac{1}{2}$ in. From the Bala Beds of Desertcreat. In the Museum of Practical Geology.

General Description.— The *Cyrtocerata* in the Desertcreat schists seem to have been subject to pressure in every direction, and accordingly the fossils are contorted into a variety of shapes; but amongst all those described by Portlock under the titles *Phragmoceras inæquiseptum*, *P. Brateri*, and *P. arcuatum*, only one species seems to be represented. The least contorted seems to be that called *P. Brateri.* The section is elliptic (fig. 5*a*), the long diameter in the plane of curvature, though in contorted examples it is not so. The long diameter may have any ratio to the short less than 2 to 1. The curvature is seen both on concave and convex sides, the radius of the latter being $2\frac{1}{3}$ inches. The mean rate of increase of the long diameter is 1 in 5. No surface is seen in the specimen called *P. Brateri*, but an example in the Dublin Museum from the same locality shows the surface beautifully covered by fine upward imbrications 6 per line, with intermediate ones on the back. These run sigmoidally, the chief concavity

being in the side. The body-chamber is at least half as long again as the diameter at its base, and the aperture is parallel to the lines of growth. The septa are $\frac{1}{11}$ the diameter apart. The sutures rise to the concave side, and tend to become sigmoid. In this species the considerable curvature, the moderate rate of increase, and the closeness of the septa are characters which are not very much interfered with by contortion, but the section seems capable of taking any shape, and hence the variety of names.

Relations.—The *Phragmoceras Brateri* of Münster ('Beiträge,' tab. 1, fig. 10, p. 105) has its curvature in the plane of the short diameter, and has a longer body-chamber. Moreover it is a Devonian species. The *Phragmoceras arcuatum* of Sowerby ('Silurian System,' pl. 10, fig. 1*a*, p. 621) seems to be really a *Phragmoceras*, and there is no sign of the poor specimen referred to it by Portlock having a contracted aperture. The present species differs from *Cyrtoceras subarcuatum*, which occurs in the same rocks, by its greater curvature, slower increase, and more oblique septa.

Distribution.—The whole of those examined have come from the shales of the Bala period at Desertcreat (6). A contorted specimen from the Bala Limestone of Sholeshook may belong to it.

It is recorded also by Salter from the same horizon, south of Llangollen.

CYRTOCERAS LLANDOVERI, Blake, Pl. XXI. figs. 1, 1*a*.

Type.—Section oval; the long axis being in the plane of curvature. The mean radius of external curvature is 17 inches when the mean diameter is 3 inches, but the curvature is not very regular. The long diameter increases at the rate of 1 in 4. No surface or body-chamber is seen, all being the cast of the septate portion. The surface of the septa is not seen. They are distant $\frac{1}{6}$ of the long diameter. The sutures are slightly concave towards the inner edge, but towards the outer side they bend backwards and become convex. The siphuncle is a remarkable one; its centre is situated at $\frac{1}{6}$ the long diameter from the outer edge, and has itself a diameter equal to $\frac{1}{6}$ the same; it narrows instead of expanding between the septa, and its surface is marked by a number of longitudinal impressed folds; on the upper part of the inner edge there is a conical hollow in the cast indicating some prominence in the shell. The greatest length is 5 inches, and the greatest diameter $2\frac{1}{2}$ inches. From the Upper Llandovery rocks at Craig-yr-Wyddon. In the Woodwardian Museum.

General Description.—Although I have seen specimens which might possibly be referred by their general dimensions to this species, and whose siphuncles are unseen, yet, as the great character is the form of that organ, the example must at present be considered unique.

Relations.—A magnificent species figured by Barrande ('Syst. Silur. de Bohême,' pl. 483, 484), under the name of *Cyrtoceras turnus*, has a siphuncle of similar characters to the present, viz. its narrowing between the septa and its longitudinal lines, and a side view of the shell is similar in general appearance. The siphuncle, however, is close to the convex side, and attains a diameter of only $\frac{1}{20}$ instead of $\frac{1}{6}$ the whole diameter of the septum, while the section of the shell is much more transverse. The sutures, moreover, are perfectly straight, and not sigmoidal. Although, therefore, they belong to the same group, these differences seem worthy of recognition by giving a distinct name for the present form. Barrande's species comes from his stage G, or highest part of the Upper Silurian rocks, whereas ours comes from the lowest.

Distribution.—In the Upper Llandovery rocks of Craig-yr-Wyddon (1).

Section Exogastrica.

CYRTOCERAS APPROXIMATUM, Sowerby, Pl. XX. figs. 1, 1*a*.

1838. ORTHOCERAS APPROXIMATUM, Sowerby in Murchison's 'Silurian System,' pl. 21, fig. 22.
1854. CYRTOCERAS APPROXIMATUM, Morris, 'Catalogue of British Fossils,' p. 302.

Type.—The section is circular. The rate of increase is very slight at the smaller end, and almost zero at the larger. The curvature is slight, having a radius of $7\frac{1}{2}$ inches. The surface is only seen by the external cast. The appearances presented are rather contradictory. In the part preserved the septa appear to be $\frac{1}{4}$ the diameter apart, but on the external cast there are lines which are twice as close; these may be interpreted either as ribs or septa. The apparent remoteness of the latter on the upper part would lead to the former, but another specimen suggests the latter, interpretation. The convexity is moderate, and the siphuncle minute and external. From the Upper Llandovery Sandstone of Eastnor Park. In the Museum of the Geological Society.

General Description.—A better preserved example, apparently referable to this (fig. 1), shows a section with equal axes, but scarcely circular; the increase is greater on approaching the inflated body-chamber, which is $\frac{5}{8}$ its basal diameter in length, and the aperture has a simple circular outline. The curvature is almost lost. The septa in this are certainly $\frac{1}{8}$ the diameter apart, but no siphuncle can be found on the rather conically-shaped septal surface (fig. 1*a*).

Relations.—The nearest species to this in shape is *Orthoceras fretum*, but there is no sign of curvature in that, and the body-chamber is different.

Distribution.—In the Upper Llandovery, Eastnor (1), and in Wenlock Beds (?), Dudley (1).

Cyrtoceras corniculum, Barrande, Pl. XIX. figs. 8, 8*a*.

1866. Cyrtoceras corniculum, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 121, p. 492.
1873. „ „ Salter, 'Cambrian and Silurian Fossils,' p. 160.

Not Cyrtoceras corniculum, Eichwald, 'Leth. Rossica,' pl. 47, fig. 11, p. 1288.
Nor „ „ Hall, 'Rep. Geol. Surv. Wisconsin,' i. figs. 1, 2, p. 41.

Type.—Section elliptic in the ratio of 17 to 13, with the long axis in the plane of curvature. The mean radius of curvature, for specimens of average size (*i.e.* of greatest diameter $1\frac{1}{2}$ inches), is $2\frac{1}{4}$ inches. The rate of increase of the long diameter is 1 in 3. The surface is ornamented with ridges of growth, varying in strength, and distant about 2 per line, but the cast is smooth. The body-chamber is short, its length being about $\frac{2}{3}$ the long diameter of its base. The aperture is very simple, having a slightly convex margin and very little sinus on the front. There may be a thickening of the shell a little way below it. The septa have very little convexity, and are distant $\frac{1}{9}$ the mean long diameter. The sutures are only slightly concave on the sides, and incline forwards towards the outside. The siphuncle is near, but not at, the convex border, and is narrow and scarcely inflated between the septa. Length, about $3\frac{1}{2}$ inches; greatest diameter, about $1\frac{1}{2}$ inches. From stage E, or Upper Silurian.

General Description.—The specimen referred by Salter to this species, which is figured (fig. 8), has an elliptic section, with the axes in the ratio of 18 to 15, the curvature being in the plane of the longer diameter. Both this and others are therefore rounder than the type. The mean radius of curvature is $2\frac{3}{4}$ inches. The long diameter increases at the rate of 1 in 3, or a little more slowly in some. The surface shows only fine transverse lines of growth, but the specimens are mostly casts. The body-chamber is short. The aperture has a convex outline passing on the front to a well-marked sinus, and below it, in one example, is a broad depression due to a thickening of the shell. The surface of the septa is not very convex, and they are distant $\frac{1}{10}$ of the mean long diameter. The sutures have only a slight concavity, and bend forwards rapidly towards the outside. The siphuncle is not satisfactorily seen, and therefore probably not bulbous, but it appears to be external. The largest specimen is 3 inches long by $1\frac{1}{2}$ inches in greatest diameter.

Relations.—The British species present some little differences from the Bohemian, but the reference is probably right. This has nothing to do with the species figured by Eichwald nor with that figured by Hall, which have by chance been called by the same name. There is very considerable resemblance between this and *C. inæquiseptum* in shape of section, rate of increase, radius of curvature, and distance of septa, but the sutures in the present pass forwards to the outside, but in that species

towards the inside, and this difference may possibly be associated with a different position of siphuncle.

Distribution.—In the Wenlock Shale, Dinas Bran (1) and Duke's Quarry (1); in the Wenlock Limestone, Dudley (1).

Cyrtoceras isca, Blake, Pl. XIX. figs. 6, 7.

Type.—The specimen (fig. 7) is flattened, and does not give its true shape. The curvature is moderate, the mean radius being 2 inches for the external curve. The long diameter, which is in the plane of curvature, increases in the flattened shell at the rate of 1 in 4. The surface shows feeble signs of forward imbrications (better seen in other examples), about 2 per line. The body-chamber is seen for a length of 7 lines, and there is no change on approaching the further end. The septa are very numerous, from $\frac{1}{15}$ to $\frac{1}{22}$ the long diameter apart, the last few being the closest. The sutures are sigmoidal, rapidly curving forward in the middle of the side, and bending round so as to pass straight over the convex side. The siphuncle is external and bulbous. Length, $1\frac{1}{2}$ inches; diameter, 1 inch. From the Wenlock Limestone, Garcoed, near Usk. In the Museum of Practical Geology.

General Description.—The specimen above described is not in some respects the best preserved, but is taken as the type as best showing the septal characters. The section is elliptic, the diameters in the ratio of 24 to 19, the longer one in the plane of curvature. The curvature is never great, the type having a maximum. The rate of increase is rather greater than 1 in 4. The ornaments are direct, forward imbrications, from $\frac{2}{3}$ to $\frac{1}{2}$ a line apart (fig. 6), convex towards the aperture. These cease on the body-chamber, and give place to lines of growth. There is some appearance in one specimen of the aperture having been contracted like a *Phragmoceras*, but there is no other change in the shape of the body-chamber. The septa are very slightly convex, very close and sigmoid. The siphuncle in all is external and bulbous.

Relations.—This species runs very close to two others, but could not well be placed with either of them. The closeness of the septa, the position and form of the siphuncle, and the general rate of increase bring it very near to *C. fortiusculum*, but that is a smooth species, while this is ornamented. It has also its sutures sigmoidal, and perhaps even closer, and its curvature is less. On the other hand, *C. quasi-rectum*, var. *contraria*, has ornaments of rather a different character, which alone would be of comparatively little consequence, but the general shape of the one is altogether different from that of the other, and the septa have a greater average closeness.

Distribution.—In the Wenlock Limestone of Garcoed, Usk (3); all these examples are in the Museum of Practical Geology.

Cyrtoceras contrarium, Barrande, Pl. XIX. figs. 9, 10.

1866. Cyrtoceras quasi-rectum, *var.* contraria, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 146, p. 586.

Type.—The normal form named *quasi-rectum* (described by Barrande on p. 669 and figured in pl. 160, figs. 1–9, and pl. 163) has a section which varies from circular to elliptic, with the axes in the ratio of 8 to 7; but the variety *contraria* has them as 7 to 6. The curvature, which is in the plane of the long axes, is zero on one side and very slight on the other, only manifest indeed towards the apex in the variety *contraria*. The increase of the diameter is variable, at first 1 in 3 and later 1 in 7 or 9. The ornaments are strong rib-like undulations, tending to imbricate upwards, low, round, and ill-defined, at a variable distance apart, much closer at first and becoming more irregular at last, the mean distance being about $\frac{1}{12}$ the long diameter, nearly straight on the type and coming to a very slight sinus on the concave side, but in the var. *contraria* sloping backwards to the convex side. These ribs are covered by from 5 to 8 parallel riblets, giving them their ill-defined character. The length of the body-chamber is about equal to the diameter at its base. The outline of the aperture, which is not at all contracted, is as transverse as the ribs are, and has a slight sinus on the same side as the siphuncle. The septa have a convexity of $\frac{1}{6}$ of the long diameter, and are distant $\frac{1}{9}$ to $\frac{1}{12}$ of the same. The sutures are nearly straight, and, though not always parallel to the ribs, are yet oblique in the same direction and nearly to the same amount as they are. The siphuncle is said to be cylindroid and not nummuloid, its longitudinal axis being greater than its transverse, but it is inflated between septa and is therefore bulbous. Moreover, while the normal form is ranged among those with cylindroid siphuncle, the variety *contraria* is classed with the species having a nummuloid siphuncle. It is situated in the normal form near the concave margin, but in the variety *contraria* near the convex margin, whence the name of the variety. Length, $2\frac{3}{4}$ inches; greatest diameter, $1\frac{1}{2}$ inches. From stage E in the lower part of the Upper Silurian.

General Description.—The British forms are very characteristic fossils, and apparently abundant in one locality. The section is a compressed oval, whose length is due in all probability to pressure, as several are changed in their shape from that cause; the ratios of the diameters in this way vary from 11 to 6 to that of 12 to 9. The curvature on the convex side is almost confined to the earlier portion, and the usually concave side is flat, except near the apex, where it also is convex. Thus the rate of the increase of the diameter is variable, at first 1 in 6, but later becoming almost zero. The surface is ornamented by undulating, rough ribs, with parallel riblets of irregular character, narrow towards the apex, then becoming stronger, and again diminishing towards the aperture; they slope a

little backwards and meet in a rounded curve on the convex side. The length of the body-chamber is not seen. The aperture is simple and parallel to the ornaments. Very few septal characters are seen: one specimen shows the septa $\frac{1}{12}$ the long diameter apart, and the siphuncle, composed of spherical bulbs, on the outer curve. In the rest the septa are either invisible, or the siphuncle has been displaced so as to occupy the middle of the side. Greatest length, 3 inches; greatest diameter, 16 lines.

Relations.—The external peculiarities of the British forms are so faithfully reproduced in those which Barrande has figured and described as *Cyrtoceras quasi-rectum*, that, in spite of some minor differences, it seems proper to refer them to that species. These differences are, first, that the siphuncle is bulbous in ours and not so markedly so in the Bohemian; secondly, it has only been seen external, which is only the case in a variety of Barrande's; thirdly, the section, though undoubtedly compressed, never makes any close approach to being circular. In regard to the last two points, the forms figured as *C. ambiguum*, by Barrande, approach nearer to ours, but not in regard to the first point.

Distribution.—In the Wenlock Shale of the Usk district (12) and in the Wenlock Limestone of the same district (1).

Cyrtoceras plebeium, Barrande, Pl. XIX. fig. 5.

1848. Cyrtoceras plebeium, Barrande, 'Haid. Ber.' iv. p. 208.
1866. „ „ Barrande, 'Syst. Sil. de Bohême,' pl. 109, 208, p. 525.

Type.—The section is oval, the ratio of the diameters being as 8 : 7. The curvature has a radius of about 1 inch. The body-chamber is a little longer than its basal diameter, and the aperture is a simple curve. There are no ornaments beyond lines of growth. The septa have a slight curve backwards on the side, and forward on the convex border. They have a convexity of $\frac{1}{4}$ the diameter, and are distant $\frac{1}{8}$ the diameter. The siphuncle is almost external; it is cylindrical, and $\frac{1}{12}$ the whole diameter. The length is about $2\frac{1}{2}$ inches. From the beds D_1, E_1, E_2.

General Description.—Some little specimens, flattened in the Wenlock Limestone, agree, so far as their characters are preserved, with this species. They have a curvature of about 1 inch radius, the diameter being $\frac{1}{6}$ inch. The rate of increase is about 1 in 6. The body-chamber is short, if the aperture is reached. The septa are gently concave forward, and are distant $\frac{1}{6}$ to $\frac{1}{7}$ the diameter. No siphuncle is preserved. The length is about $1\frac{1}{4}$ inches.

Relations.—This gently-curved graceful *Cyrtoceras* cannot be confounded with any other; the nearest being *C. macrum*, which has less curvature, and is altogether a stouter shell.

Distribution.—In the Wenlock Limestone of Dudley (2).

CYRTOCERAS COMPRESSUM, Sowerby, Pl. XVIII. figs. 1, 2.

1838. PHRAGMOCERAS COMPRESSUM, Sowerby in Murchison's 'Silurian System,' pl. 11, fig. 2, p. 621.
1873. CYRTOCERAS? COMPRESSUM, Salter, 'Cambrian and Silurian Fossils,' p. 160.

Not 1843. PHRAGMOCERAS COMPRESSUM, Portlock, 'Geol. Report,' p. 282.

Type.—Only a portion is seen, in which the rate of increase apparently decreases very rapidly so as to be almost zero at last. The curvature at first has a radius of about $1\frac{1}{4}$ inches, but at last of $2\frac{1}{4}$ inches only, the mean diameter of the shell being 1 inch. The surface shows that the shell was thin, and ornamented by feeble riblets of growth, 3 per line, which curve backwards and cut the septa obliquely. The septa are about $\frac{1}{10}$ the diameter of the whorl apart; the sutures are not very concave and bend back slightly towards the outside, so as to be sigmoid. The body-chamber extends for $1\frac{1}{3}$ inches, at a less curvature than the rest, and shows no signs of any contraction near the aperture. Curved length, $4\frac{1}{2}$ inches. From the Lower Ludlow rocks, Aymestry. In the Museum of the Geological Society.

General Description.—The section was probably elliptic, but in none is it perfectly preserved. The rate of increase is about 1 in 5 in the earlier portions, or even greater from contortion, but reduces to almost zero at last. The mean curvature is considerable, having a radius of $1\frac{1}{2}$ inches when the mean diameter of the shell is more than 1 inch. The body-chamber is as long as its basal diameter, and shows no change at the aperture. The ornaments, when preserved, are transverse sharp lines of growth, rather sigmoid in outline and cutting the sutures towards the outside. The septa are approximate, concave on the side, but really sigmoid; they are very close, occasionally extremely so (fig. 2). The siphuncle is external and bulbous. The type is as large as any.

Relations.—The ornaments are something like those of *Trochoceras cinereum*, but not so pronounced, and the present species appears to be a genuine *Cyrtoceras*. It is also very like *Trochoceras striatum* when found in fragments, but complete shells are immediately distinguishable.

Distribution.—In the Lower Llandovery, Thrave (1); in the Coniston Grit, Brownthwaite (1); in the Lower Ludlow of Aymestry (1), Leintwardine (1), Aston (3), Stoke Wood (1), Ledbury (4), and of Usk (2); and from the Upper Ludlow, Ludlow (2).

It is also recorded by Lapworth from the Upper Silurian of the Pentlands; by Salter from Lower Ludlow, Parkes Hall; in the Catalogue of Western Scottish Fossils, from Penkill.

CYRTOCERAS MAGNUM, Blake, Pl. XXVII. figs. 3, 3*a*.

Type.—The section is sub-sagittate, *i.e.* it is flattened on the convex side, but more acute on the convex. The larger axis is to the shorter as 3 to 2. The curvature is slight, the radius being $4\frac{1}{4}$ inches when the diameter of the shell is a little more than 3 inches. The rate of increase is 1 in 2. Very little body-chamber and no surface is seen. The septa are slightly sigmoid, curving forward on the convex side. They are distant $\frac{1}{11}$ the mean diameter. The siphuncle is unseen. Length, $3\frac{1}{2}$ inches. From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.

General Description.—Whether any other examples of this species have really been seen is somewhat doubtful, though specimens of some size—expanding at a rapid rate, as this should do, when smaller—with a large radius of curvature are seen; but they have a more elliptic section, and some show lines of growth. The septa are radial, and distant $\frac{1}{7}$ to $\frac{1}{10}$ the diameter, according to size, being more remote at first. Their convexity is slight. The siphuncle is seen in these to be large, bulbous, and external.

Relations.—From its shape it would be quite possible that this should be part of a *Phragmoceras.* But from its external siphuncle, the only described form it could be is *P. devonicans,* and that has a less rapid increase. Nevertheless, were this proved to have a contracted aperture, there would be comparatively little to separate them. The nearest British form is *Cyrtoceras subarcuatum*; but if the other specimens are rightly referred to the same, that species has a central siphuncle.

Distribution.—In the Upper Silurian of Pen-y-lan, Cardiff, in beds which are considered to belong to the Wenlock, but whose fauna is mixed (1); in the Lower Ludlow, Ledbury (2); in the Upper Ludlow, Woolhope (1).

CYRTOCERAS FORTIUSCULUM, Barrande, Pl. XIII. fig. 3.

1866. CYRTOCERAS FORTIUSCULUM, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 207, figs. 13–16, p. 630.

Type.—Section oval, with the diameters in the ratio of 10 to 9, and the curvature in the plane of the long diameter. The narrower end is on the convex side. The mean radius of curvature is 14 lines when the mean long diameter is $8\frac{1}{2}$ lines. The long diameter increases at the rate of 1 in $3\frac{3}{4}$. The surface has only fine lines of growth. The body-chamber is about as long as its basal diameter. The aperture is perfectly simple, and formed by a scarcely convex curve perpendicular to the general direction of the shell. The septa have a convexity of $\frac{1}{8}$ the long diameter, and they are very close, viz. $\frac{1}{14}$ the long diameter. The sutures are but slightly concave, and

curve forward on the convex sides. The siphuncle is external and bulbous, the transverse diameters of the bulbs being greater than the longitudinal. The greatest length is $2\frac{1}{4}$ inches, and the greatest diameter 11 lines. From stage E or Upper Silurian.

General Description.—The section, as seen in an example in the Museum of Practical Geology, is nearly circular; but its longer diameter is in the plane of curvature. The mean radius of external curvature is 16 lines, the mean long diameter being 10 lines. The rate of increase is 1 in $3\frac{1}{2}$ in a flattened example, and 1 in 5 in one uncompressed. The surface is smooth on the sides, but on the concave border are rugosities which pass back over the septa, and consist of upward imbrications, thrice as numerous as they. The body-chamber has a length equal to its diameter, and the aperture, as far as seen, appears to be simple. It lies parallel to the septa, and has a slight constriction round it. The septa are very slightly convex and very approximate, being $\frac{1}{11}$ of the long diameter apart, which becomes $\frac{1}{15}$ in a flattened example. The sutures have very slight concavity, and bend forward towards the convex side. The siphuncle is external, and consists of closely-set, well-marked bulbs, whose transverse diameter is greater than the longitudinal. The largest specimen is imperfect at both ends; the greatest length is $2\frac{3}{4}$ inches, and the greatest diameter 2 inches.

Relations.—This is very closely related in many respects to *C. corniculum*, but the siphuncle is not cylindrical, as in that species, but very bulbous; other differences of less certain value are the greater curvature and the greater closeness of its septa.

Distribution.—In the Lower Ludlow of Ledbury (3).

CYRTOCERAS INTERMEDIUM, M'Coy, Pl. XX. fig. 6, Pl. XXI. fig. 2, and Pl. XVIII. fig. 13.

1851. PHRAGMOCERAS INTERMEDIUM, M'Coy, 'Annals of Nat. Hist.' Ser. II. vol. vii. p. 45.
1852. „ „ M'Coy, 'British Palæozoic Fossils,' p. 322.
1873. PHRAGMOCERAS? Salter, 'Cambrian and Silurian Fossils,' p. 174.
Syn. 1838. PHRAGMOCERAS ARCUATUM, Sowerby, 'Silurian Syst.' pl. 11, fig. 1, p. 621. Not var. *a* of pl. 10, fig. 1*a*.

Type.—Section a rather flattened oval, the larger end towards the convex side, the long axis being in the plane of curvature. The ratio of the axes is as 5 to 3. The curvature is considerable, the mean radius being only $\frac{2}{3}$ of the corresponding mean diameter, viz. about $1\frac{3}{4}$ inches. The rate of increase of the long diameter on the septate portion is 1 in 8, and this continues uniformly on the body-chamber, till near the aperture, where the surface appears to bend in as if to come to a complex aperture; but this part is not well preserved, and the appearance is no doubt due solely

to preservation. The body-chamber has a length of $\frac{4}{5}$ its basal long diameter. No surface is seen. The septa are distant $\frac{1}{9}$ the mean long diameter in the middle of the side, and the last chamber has nearly the same size as the rest. The sutures are sigmoidal, being concave to the aperture on the inner, and nearly direct on the outer, side. No siphuncle is seen. The greatest length is $2\frac{1}{2}$ inches, and the greatest diameter $1\frac{1}{4}$ inches. From the Lower Ludlow of Leintwardine. In the Woodwardian Museum.

General Description.—Another example shows the oval section, with the axes in the ratio of 4 to 3 and broadest outside. In this respect it differs from the specimen called by Sowerby *Phragmoceras arcuatum* (Pl. XX. fig. 6*a*), which is broadest inside, and almost sagittate; but as all the fossils have obviously been subject to much compression, and probably distortion, this alone cannot be of great consequence. The body-chamber in one is as long as its basal diameter, but the septal characters are the same as in the type. If rightly determined, the siphuncle in Sowerby's specimen is minute and external.

Relations.—The rate of expansion is not so great as in *C. corniculum*, and the direction of the septa is different, and the curvature greater than in *C. inæquiseptum*. There are no indications of this being a *Phragmoceras*.

Distribution.—In the Lower Ludlow of Leintwardine (3) and of Ludlow (1), and a small specimen possibly of this species (Pl. XVIII. fig. 13) in the Wenlock Series ? Dudley.

Cyrtoceras Uranus, Barrande, Pl. XXI. fig. 3.

1866. Cyrtoceras Uranus, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 196, figs. 12–18, p. 644.

Type.—Section subquadrately elliptical, with the long diameter in the plane of curvature. Ratio of diameters 7 to 6. Mean radius of external curvature $2\frac{1}{2}$ inches, the mean diameter being $1\frac{3}{4}$ inches. The long diameter increases at the rate of 1 in 4. The surface is ornamented with raised lines which curve backwards, cross the septa, and make a sinus on the front. There are also longitudinal lines which are scarcely to be seen except in the young. The body-chamber is not longer than the diameter of its base, and the aperture is simple and directly transverse. The septa have a convexity of $\frac{1}{4}$ the long diameter. They are distant $\frac{1}{3}$ the long diameter in the middle of the side. The sutures are undulating, in such a way that they would be direct if they did not make a shallow sinus in the middle of the side. The siphuncle has its centre at $\frac{2}{3}$ the diameter from the inner side. It is very slightly inflated to $\frac{1}{5}$ the long diameter. The largest specimen figured has a length of $4\frac{1}{2}$ inches, and the greatest diameter $2\frac{1}{4}$ inches. From stage E or Upper Silurian.

General Description.—The example referred to this species presents so remarkable an agreement with the above description in its size, its curvature, its rate of increase, the characters of the septa and the sutures, that the details need not be repeated. It has, however, suffered some compression, which has rendered the section a more elongated ellipse, of which the axes are nearly as 2 to 1. The ornaments are fine raised lines distant $\frac{1}{2}$ line on the front, somewhat imbricating forwards, but with their curvature backwards, making a sinus on the front. No longitudinal lines have been observed. The whole is septate, and the sutures pass a little more forward on the convex side than in Barrande's figure. The siphuncle is not well seen, but seems to be of moderate size, and situated about halfway between the centre and the convex edge.

Relations.—This species, as Barrande remarks, has some resemblance to a fragment of a *Nautilus*, but he has found a large example showing it to form less than a complete whorl; but in fact the rate of increase as compared with the curvature is so great, or, in other words, the angle of the spiral is so small, that a complete whorl would be of enormous size. We need not, therefore, really compare it with the *Nautili*, and its general form and remote septa only allow of its comparison with *Cyrtoceras llandoveri*, whose siphuncle at once distinguishes it.

Distribution.—From the Lower Ludlow rocks of Ledbury (1), in the collection of Dr. Grindrod.

CYRTOCERAS (?) EQUISETUM, Blake, Pl. XXX. fig. 7.

Syn. 1838. PHRAGMOCERAS NAUTILACEUM (part), Sowerby in Murchison's 'Silurian System,' pl. 10, fig. 3 (not fig. 2).

Type.—The section is doubtful, but at present the surface of the side exposed is uniformly convex. The curvature is very great, the mean radius being $1\frac{1}{2}$ inches when the diameter of the whorl is about $1\frac{1}{4}$ inches. Thus, though the specimen is imperfect at the smaller end and there are no signs of contact of an earlier whorl, the appearances are almost those of a coiled shell. The rate of increase is about 1 in 15, measured along the outer curve. The ornaments are very rough irregular risings, curving rapidly backwards from the inner edge, and covered with parallel irregular lines of growth. Possibly 3 inches of mean length belong to the body-chamber. There is no sign of any change towards the aperture, which will be similar to the general ribbing, and therefore have a deep sinus on the front. The septa are rather remote, being from $\frac{1}{4}$ to $\frac{1}{5}$ the present diameter of the whorl apart, or 9 in the quarter circumference seen. The sutures curve rapidly forwards towards the convex side, cutting across several lines of ornaments. The siphuncle is external. Its elements are much narrower than their length, and have a conical shape, enlarging towards the aperture, and suddenly decreasing on passing each

septum. The diameter across the shell is about 3½ inches, and the greatest diameter of the whorl is $1\frac{1}{3}$ inches. From the Lower Ludlow of Ledbury. In the collection of Dr. Grindrod.

General Description.—The roughness of the ornaments and forward curve of the septa, which in the absence of the remarkable siphuncle distinguish this species, are not commonly met with, there being only two other specimens I can refer here. One shows the same kind of ribbing dying off toward the outside and also towards the aperture, which, like the ornaments, is forward inside and curves backwards sigmoidally towards the outside. On this the radial epidermids, distant 18 per line, are well exposed. The other is one of the examples figured by Sowerby as *Phragmoceras nautilaceum.* The second, or more involute example figured by that author, must be taken as the type to retain the specific name. This one is but a broken fragment, which, however, may well be referred here by its rough ornaments and its septa.

Relations.—If this be a *Cyrtoceras*, there is very little doubt of its distinctness from all others; none of those showing so much curvature being anything like it. On the other hand, if it be a *Trochoceras*, its peculiar siphuncle, combined with the irregularity of its ribbing, separate it well from all those in which those characters are known.

Distribution.—In the Lower Ludlow of Ledbury (2), and in some Upper Silurian rock at Dudley (1).

Section Mediogastrica.

Cyrtoceras subarcuatum, Portlock, Pl. XX. fig. 7.

1843. Orthoceras subarcuatum, Portlock, 'Geol. Report,' pl. 28, fig. 9, p. 374.

1865. Cyrtoceras subarcuatum, Salter, 'Catalogue of Fossils in the Museum of Practical Geology,' p. 32.

Syn. 1843. Orthoceras breviconicum, Portlock, loc. cit., pl. 28, fig. 8, p. 373.

Type.—Section oval, with the curvature in the long diameter, and the narrower end of the oval on the convex side. The diameters are in the ratio of 21 to 13. The long diameter increases at the rate of 1 in 2. The inside edge is almost straight, and the outside edge is only slightly curved. The surface had only transverse lines of growth, nearly parallel to the septa, but increasing in strength and becoming oblique on the concave side. The body-chamber continues for 10 lines on the convex side without change. The septa have a very slight convexity; their distance increases more than proportionally towards the body-chamber, from $\frac{1}{14}$ to $\frac{1}{12}$ the corresponding long diameter. The sutures are slightly undulating, the convexity being on the inner side; the direction is at right angles to the inner edge of the

shell. No siphuncle is seen. Length of specimen, 22 lines; greatest diameter, 21 lines. From the Bala Beds, Desertcreat. In the Museum of Practical Geology.

General Description.—The specimen figured by Portlock as *O. breviconicum* has been much distorted and compressed, the result being a greater apparent expansion. The shape of the present section shows this, being altogether irregular. Allowing for this compression, all the other features agree with the above, and confirm the lines of growth nearly parallel to the sutures, the slight undulation of the sutures, and the flatness of the septa. It shows also a minute and central siphuncle. Another smaller specimen shows the septa as usual, at about $\frac{1}{11}$ the diameter apart, and the lines of growth curving backwards on the convex side.

This brevicone *Cyrtoceras* is of especial interest, as being of that group which will lead on to the *Phragmocerata*, the flatness of the septa being a point of alliance. There is not, however, in these the slightest sign of contraction near the aperture, nor of change in the general shape of the body-chamber.

Relations.—There cannot be the slightest doubt, after an examination of the specimens, of the identity of the two species united. This species differs from *C. sonax* in its less curvature and more rapid increase, and in the position of the siphuncle.

Distribution.—In the Bala Beds of Desertcreat (4). I have not seen any that could be certainly referred to this species from other localities, but Lapworth records it from "Middle Silurian," Girvan, and an example in the Museum of Practical Geology from Rhiwlas Bala has a similar rate of increase and like ornaments, but its section is nearly circular. This may perhaps be the true uncompressed form of the species, but this single specimen has not sufficient characters to prove it.

Cyrtoceras extricatum, Blake, Pl. V. figs. 10, 11, 11*a*.

Syn. 1838. Lituites articulatus (part), Sowerby in Murchison's 'Silurian Syst.' pl. 11, fig. 7 (not the others).
1852. " " M'Coy, 'Pal. Foss.' p. 323.

Type.—The section is circular. The rate of increase in the septal portion is unseen, the example chosen as type consisting of body-chamber only, which decreases towards the aperture (fig. 10, reversed by the artist). The mean radius of curvature is $2\frac{1}{3}$ inches at a diameter of $\frac{3}{5}$ inch. The body-chamber is four times as long as its basal diameter. The aperture is circular and not marked by any constriction. The ornaments are strong radial non-separate ribs, about $\frac{1}{3}$ the diameter apart; the shell surface is not preserved. The septa are parallel to the ribs, and the convexity is nearly equal their interval. The siphuncle is small and nearly central. Length, $2\frac{1}{3}$ inches. From the Lower Ludlow, Mocktree. In the Ludlow Museum.

General Description.—Another example of body-chamber, figured (fig. 11), shows

still more clearly the contraction towards the aperture, round which the ribs are more approximate, but otherwise it is simple. The curvature is uniform both here and in septal portions. The peculiar irregular running of the ribs is shown. These are always strong; but no finer ornaments have been observed. The septa show very great convexity, and lie in the spaces between the ribs, and are thus about $\frac{1}{3}$ the diameter apart. The siphuncle is often seen small and central.

Relations.—This species has entered into the confusion that has arisen over the curved and straight transversely-ribbed species. First, Sowerby thought it might be the straight portion of his *Lituites articulatus*—now *Ophidioceras.* The distinctness of the latter has long been seen. Next, the quite straight *Orthocerata* were confounded with it, and this was placed with *O. ibex.* Now that nearly complete straight shells of the latter have been seen, it is known never to be curved. The ribs too and the circular form of the present species ought easily to separate it. Again, it is similar to the curved shells which may be true *Lituites*, but is more robust, and the specimens figured prove it to have a quite different aperture. It is indeed a *Cyrtoceras*, which none of the others are, and it appears to be not an unusual thing, to judge by Barrande's figures, for *Cyrtocerata* of this ribbed and mediogastric group to contract in the body-chamber. The present species is very like several figured by that author, but has coarser ribs than any.

Distribution.—In the Lower Ludlow of Mocktree (3), of Aymestry (1), Dudley (1), and Welchpool (1).

Position of Siphuncle not indicated.

Cyrtoceras multicameratum, Hall.

See M'Coy, 'Palæozoic Fossils,' p. 312, and Salter, 'Cambrian and Silurian Fossils,' p. 37.

I have not been able to prove to my own satisfaction that this species really occurs in Great Britain. The specimen referred to it by M'Coy, and subsequently by Salter, is in the Woodwardian Museum at Cambridge. It is some curved organism in a concretionary limestone, and its surface is utterly eaten out by atmospheric agencies. There *appear* to be a number of knobs arranged in longitudinal lines, with intervening longitudinal ribs; but the whole appearance may be only due to weathering: just so the supposed septa, for between these knobs are transverse lines which have been considered to be sutures. The general shape is certainly that of a small *Cyrtoceras*, or of a small coral, and I see no proof of its being one of these rather than the other.

This is the only specimen referred to the species I have seen, though it has been recorded from Wrae and Girvan by Lapworth. The best collection of the fossils from the latter locality having been withheld from my inspection, I am

unable to say whether any more characteristic specimens exist, and am obliged to leave the species as a doubtfully British one.

Distribution.—The species is said to come from the Lower Bala Beds of Knockdollian, Ayrshire. There is also a specimen in the Museum of Practical Geology from the Durness Limestone, apparently the one figured in 'Siluria,' Fossil group 27, fig. 5, as *Oncoceras*, whose peculiarities as shown in that figure are due *entirely* to preservation, but which by the closeness of its septa might belong to the present species.

Cyrtoceras scoticum, Blake, Pl. XXI. figs. 4, 4*a*.

Type.—Section elliptic, with the shorter axis in the plane of curvature. Axes at last in the ratio of 7 to 6. The curvature is great, the mean radius being about 7 lines. The rate of increase is 1 in 2 at first, but rapidly diminishes to zero in the body-chamber. There are signs of the surface having had transverse rugosities of growth, but on the whole it is smooth. The septa are direct, at a variable distance, on the average $\frac{2}{5}$ the diameter. No siphuncle is seen. The initial point is beautifully shown; it has a cicatrix. The diameter of the whole shell is about $1\frac{1}{4}$ inches; the diameter at the aperture is $\frac{1}{2}$ inch. From the Bala Beds of Broughton. In the Museum of the Geological Survey, Edinburgh.

General Description.—The type is unique.

Relations.—In the great amount of curvature this is very near to *Cyrtoceras circumflexum* and *C. cycloideum* of Barrande, but in the present case it is the short and not the long diameter that is in the plane of curvature. Moreover, the septa are much wider apart.

Distribution.—In the Bala Beds, Broughton, Ayrshire (1).

Cyrtoceras alternatum, Blake, Pl. XX. fig. 4.

Type.—Section elliptic, diameters in the ratio of 9 to 8, and the long diameter in the plane of curvature. The radius of curvature increases from $3\frac{1}{2}$ inches to 6 inches. The long diameter increases at the rate of 1 in $6\frac{1}{2}$. The surface is ornamented by transverse, rounded, not very separate ribs $\frac{1}{4}$ the diameter apart, alternately larger and smaller, which run obliquely upwards towards the convex side, making an angle of 4° with the axis of the shell. No finer ornaments are preserved; but there are indications of possible fine longitudinal lines running over the ribs. The specimen is all septate, but the surface of the septum is not seen. The distance of the septa is $\frac{1}{2}$ the short diameter. The sutures are straight and rise to the convex side parallel to the ribbing, and lie in the hollow in front of the larger rib. No siphuncle is seen. Length, 15 lines; greatest diameter, $3\frac{1}{2}$ lines. From the Bala Beds at Bryn Bedwog, near Bala. In the Museum of Practical Geology.

General Description.—The type is unique.

Relations.—There is a group of small ribbed *Cyrtocerata*, figured by Barrande, to which this species belongs, amongst which *C. urbanum* ('Syst. Silur. de Bohême,' vol. ii. pl. 198, figs. 11–20) alone agrees with it in having the ribs rising to the convex side; but they are of equal size throughout, and there is a septum between each.

Distribution.—In the Bala Beds, Bala (1).

Cyrtoceras (*Piloceras*) *invaginatum*, Salter.

See Salter, 'Quart. Journ. Geol. Soc.' vol. xiv. pl. 13, figs. 17–21, p. 376.

I have little to add to the remarks on the *Piloceras* as a genus, in which I throw doubt on its being a Cephalopod at all. I have been to Durness to see if it were possible to find any septa passing beyond the fossil in the matrix, but without success; neither the collectors there, nor Mr. Peach, their original discoverer, ever saw septa extending beyond them, and there are no signs of any such in the numerous specimens in the Museum of Practical Geology, of the Royal College of Science, Dublin, or elsewhere. The surface, however, is probably worn away in all the specimens; and the rings figured by Salter, and considered by him as ornaments, but by Barrande as the junction of septa to the siphuncle, may be due only to weathering. The sheaths are parallel to each other and to the exterior, which is one of them, so that the manner in which the inner ones are supported has not been made out. I doubt if there ever was an interval between them not filled by any organically formed material, for had there been they must have floated loosely one inside the other. The organism, whatever it is, must wait elucidation by materials not yet extracted from the rocks.

Group II. Inflati.

Genus Poterioceras.

Poterioceras (?) approximatum, M'Coy, Pl. XXIV. fig. 6.

1846. Poterioceras approximatum, M'Coy, 'Silurian Fossils of Ireland,' pl. 1, fig. 5, p. 10.
Syn. 1843. Gomphoceras subfusiforme, Portlock, 'Geological Report,' pl. 24, fig. 5.

Type.—The section is now elliptic, perhaps by compression. The curvature is uniform on both sides; the general radius of curvature being 16 lines. The rate of increase on the septate portion is 1 in 4; the greatest diameter being opposite the last chamber, and the body-chamber decreasing again with the same curve. No aperture is seen. The septa are about $\frac{1}{10}$ the long diameter apart, and the sutures are nearly direct. Greatest length, 14 lines; greatest diameter, 9 lines. From Lower Silurian Sandstone at Pomeroy. In the Museum of the Royal Dublin Society.

General Description.—No examples show the outline better than the type, all of them being contorted. Nor is the curvature on both sides so equal in others, but both the specimen referred by Portlock to *Gomphoceras subfusiforme* and the figured example show a gradual contraction to an apparently simple aperture, the body-chamber being about equal in length to the septal portion. In the latter there appears to be considerable convexity of septa, and there is a well-marked external siphuncle on the more convex side.

Relations.—This, with *P. intortum*, first introduces the *Inflati* into the British rocks; and the latter, besides the peculiarity at its aperture, which may be abnormal, is a stouter shell in comparison to its length.

Distribution.—In the Bala Beds of Desertcreat (2), Pomeroy (1), and Twllddu, Carnarvon (1).

POTERIOCERAS (?) INTORTUM, Blake, Pl. XXIV. fig. 4.

Syn? 1843. GOMPHOCERAS SUBPYRIFORME, Portlock, 'Geol. Report,' pl. 28A, fig. 1 (not of Münster).

Type.—Section oval, the long diameter in the plane of symmetry, and the greatest breadth $\frac{2}{3}$ along the diameter nearest the more convex side. Ratio of diameters, 19 to 15. The general shape is irregular, with a very slight general curvature. The rate of increase on the septal portion is about 1 in 2, the greatest diameter being at the last septum, from whence on the body-chamber a decrease takes place towards the aperture. The sides are nearly straight, tapering at the rate of 1 in 3, but the dorsal border is more regularly convex than the ventral. The shell thickens near the aperture, but at last a sudden inbending takes place to an opening much smaller than the general section. This may, of course, be an abnormal feature. The shell is of considerable thickness, and has feeble, rather regular transverse lines of growth. The septa have a very slight convexity, and are $\frac{1}{9}$ the mean diameter apart. The sutures are nearly direct, but slightly undulating on the side. The siphuncle is not certainly seen, but appears to be nearly external on the more convex side. Greatest length, $2\frac{1}{2}$ inches; greatest diameter, 19 lines. From Bala Beds at Piedmont, Ayrshire. In the Museum of Practical Geology.

General Description.—The fossil figured by Portlock, and referred by him to *G. subpyriforme* of Münster, may belong to this species, but it is flattened out, and its true section cannot therefore be known; moreover its aperture is wanting, and the position of its siphuncle is unknown. Thus the remarkable inbending at the aperture, as seen in the type, remains unconfirmed.

Relations.—The greater width in comparison to the size, when both are equally flattened, separate the two Portlockian fossils, and also the better preserved forms to which they are severally referred. The *Gomphoceras primum* of Barrande bears a

very close resemblance to Portlock's specimen, but the body-chamber continues to increase towards the aperture instead of decreasing.

Distribution.—In the Bala Beds of Piedmont, Ayrshire (1), and of Desertcreat (1).

Genus GOMPHOCERAS.

GOMPHOCERAS ÆQUALE, Blake, Pl. XXVI. figs. 6, 6*a*, 6*b*.

1873. GOMPHOCERAS ÆQUALE, Salter, 'Camb. and Sil. Fossils,' p. 160 (name only).

Type.—Section nearly circular, the longer diameter in the plane of symmetry. General direction straight, the two sides gently and equally convex. The body-chamber commences at or before the greatest diameter, and converges towards the aperture. Its length is $\frac{2}{3}$ the basal diameter; the aperture is produced, with a constriction round it; the ventral opening is not separate from the passage, which is rather wide; the dorsal opening is a transverse ellipse, with a minor axis a little larger than the diameter of the passage, and the major twice the minor. The septa are very flat, and at a distance of about $\frac{1}{6}$ the greatest diameter. The sutures are slightly undulating, and the siphuncle small and central. Greatest length, 20 lines; greatest diameter, $14\frac{1}{2}$ lines. From the Wenlock Limestone, Dudley. In the Woodwardian Museum.

General Description.—The section is to a certain extent dependent on pressure, the axes varying from equal to a ratio of 2 to 1, but the longer one always in the plane of symmetry, showing that the true shape is more or less elliptic in that direction. The general direction of the axis of the shell is straight. The curvature on each side is slight, forming part of an ellipse with axes of about 2 inches and $1\frac{1}{2}$ inches. Thus the body-chamber and the septal portion alike have curved outlines. The rate of increase is greater than 1 in 2. The body-chamber is from $\frac{3}{4}$ to $\frac{2}{3}$ the basal diameter in length. It becomes elliptic at the top, even if the septal section is circular. The aperture occupies the top, and has a general horizontal direction. Its pattern in all agrees with that of the type. The septa are very flat, so that the shell looks truncate at the end. They are distant from $\frac{1}{6}$ to $\frac{1}{8}$ the greatest diameter. The sutures are direct, but slightly undulating; the siphuncle is small, and either central or a little excentric on the long diameter towards the ventral side. The size is always small; the largest is 3 inches long by 2 inches, but they are seldom much more than 1 inch in diameter.

Relations.—This small species repeats many of the characters of *G. ellipticum*. It has the same general shape, though the curvature of the sides is less than in the latter. Its aperture is of the same type, though less complicated; yet we cannot

think them related as young and adult, for our present species has not only a central but a small siphuncle. Moreover, the earlier part of *G. ellipticum* we know to be nearly cylindrical, as perhaps that of other species is also, so that a smaller specimen of the same shape must be equally adult. The central siphuncle and simple aperture so limit the comparison that none of Barrande's species is closely comparable. Notwithstanding, a specimen flattened in shale (from Walsall), referred to this species, is very like his figure of *G. nuciforme*.

Distribution.—In the Wenlock Limestone, Dudley (10), and Wenlock Shale, Walsall (2). Possibly from the Lower Llandovery, Plumpsaint (1).

GOMPHOCERAS CORONA, Blake, Pl. XXVI. figs. 4, 4*a*, 5, 5*a*, 7.

Type.—Section elliptic; long diameter in the ratio of 10 to 9 in the plane of symmetry. Only the body-chamber known, the two sides of which are equally and very slightly convex. The length of the body-chamber is equal to its long basal diameter; the contraction to the aperture is slight. This is obscurely preserved, but seems to be remarkably simple. The septal convexity is $\frac{1}{6}$ the long diameter, and the siphuncle is situated $\frac{1}{5}$ the same line from the ventral border. The diameter and the height of the body-chamber are each 10 lines. From the Wenlock Limestone of Ledbury. In the collection of Dr. Grindrod.

General Description.—In some others the section appears to be oval rather than elliptical, the larger end being nearest the siphuncle, and the diameters reach the ratio of 6 to 5. Some small specimens referred to this have obscure indications of an aperture, like that of *E. crater* (fig. 4); others have open apertures scarcely formed, and of such a character (fig. 5) as would grow into what we may judge the adult to have. The last two septa are exceedingly close, not more than $\frac{1}{15}$ the long diameter apart.

Relations.—By the flatness of the septa, position of siphuncle, and shape of body-chamber, these are near to the young of *G. crenulare*, but the tapering of the body-chamber is different, and so is the aperture. *E. microstoma* has a circular section and a more rapid tapering to the aperture.

Distribution.—In the Wenlock Limestone of Ledbury (4) and of Dudley (1).

GOMPHOCERAS CRATER, Blake, Pl. XXIII. figs. 4 4*a*, 4*b*, 8, 8*a*.

Type.—Section circular; the general direction of the shell is straight. The body-chamber, which alone is preserved, has straight sides, so that it forms a cone. Its length is $\frac{2}{3}$ the basal diameter. The aperture has the dorsal opening on the apex, which is transversely elliptic, with axes in the ratio of 3 to 2. The passage and ventral opening are not distinct, but form, as it were, a long lobe, which slopes down the ventral side. The whole is separated from the body-chamber by a constriction.

The septa have a considerable convexity, $\frac{1}{4}$ the diameter. The sutures are direct, and the siphuncle $\frac{1}{4}$ the diameter from the ventral edge. Length of body-chamber, 1 inch; greatest diameter, $1\frac{1}{2}$ inches. From the Wenlock Limestone of Malvern. In the Museum of Practical Geology.

General Description.—The section is very often elliptic; but it is presumed that this is due to compression, as the inequality of the axes is never very great, and the longer one is always in the plane of symmetry. The body-chamber is the only part that has been preserved in any examples. This has always a length rather less than its basal diameter, and contracts uniformly to the aperture, so that its shape is conoidal. Some little differences of aperture are seen in specimens nevertheless included in the species. In many it is like the type. In some the passage and ventral opening are wider, and in one (fig. 4) the circumference (perhaps broken down) is different, and may indicate a distinct species. The shell was thick, and had rough transverse undulations and lines of growth. The septa are very convex, up to $\frac{4}{15}$ of the diameter. The siphuncle is $\frac{1}{4}$ of the diameter from the edge, and is bulbous. The type is as large as any that are found.

Relations.—The peculiar conoidal form of the body-chamber, combined with the great convexity of the septa, mark off this species very clearly. The specimen (fig. 4) very closely resembles Barrande's *G. ferum*, but in our fossil the apparent aperture is taken to be due to some defect in the preservation. *G. decurtatum* and *G. microstoma* are somewhat similar in shape, but differ in the details of the aperture and the less convexity of the septa.

Distribution.—In the Woolhope Beds, Littlehope (1); in the Wenlock Shale of Malvern (4); in the Wenlock Limestone of Malvern (5).

Gomphoceras ellipticum, M'Coy, Pl. XXII. figs. 1, 1*a*, 4.

1838. Gomphoceras pyriforme, Sowerby in Murchison's 'Silurian Syst.' pl. 8, fig. 19 (lower), and fig. 20, not upper fig. 19.
1851. Poterioceras ellipticum, M'Coy, 'Ann. and Mag. of Nat. Hist.' Ser. II. vol. vii. p. 45.
1852. " " M'Coy, 'British Palæozoic Fossils,' p. 321.
1854. Phragmoceras pyriforme, Morris, 'Catalogue of British Fossils,' p. 312 (with fig. 19 of Sowerby).
1866. Gomphoceras ovum, Barrande, 'Syst. Sil. de Bohême,' pl. 75, 84, and 105.
1867. Gomphoceras pyriforme, Dixon, 'Woolhope Nat. Field Club, Fossil Sketches,' No. 1, fig. 4, p. 136.

Type.—The section at the last septum is elliptic, the antero-posterior diameter being $2\frac{1}{6}$ inches, and the transverse diameter $2\frac{1}{3}$ inches, which is therefore the greater. The general shape of the shell perpendicular to this section is elliptic, the greatest diameter being opposite the last septum. The septal portion begins by being nearly cylindrical. After 1 inch of this from the broken end a sudden

expansion takes place, which is the commencement of the elliptic curve, which has a long axis of $3\frac{3}{4}$ inches. The body-chamber continues the curve of the septal part without discontinuity, thus contracting to the aperture; round this there is a broad depression parallel to the ornaments, which gives a produced appearance to the margins of the aperture. The shape of this is not properly seen: what is really the smaller opening is on the slanting surface. It is elliptic, with long axis in the antero-posterior direction, and the passage of junction is short and moderately narrow, but the apex which should show the larger aperture is broken away. On the side of the small aperture are seen, most marked near the middle line, a series of fine striæ, 4 per line, bending away from the aperture on both sides, and coming to a rounded angle on the middle line. These are grouped by the occurrence of stronger ones at about the interval of a chamber. They are feebler and direct on the opposite side, but are continued on the first side over the earlier cylindrical portion. The septa have, as usual, very little convexity, and are distant about $\frac{1}{11}$ the largest diameter apart. The sutures are nearly direct, but make a very feeble sinus backwards on the side of the small aperture. The siphuncle is not seen in this example, but in another figured by Sowerby, and as stated by him it is situated half-way between the centre and the outside; it is bulbous, the bulbs having a diameter $\frac{2}{9}$ that of the chamber. In the Lower Ludlow rock, Leintwardine Hill. In the Museum of the Geological Society.

General Description.—This species cannot be made to include all the elliptic-shaped *Gomphocerata* without ignoring differences on points of as great importance as the shape. The true form has a transverse elliptical section, with the shorter axis in the plane of symmetry, the two axes being in the ratio of about 5 to 6. The longitudinal section is also uniformly elliptical, the earlier end being truncated; the diameters of this ellipse being in the ratio of 2 : 3. The greatest transverse diameters are opposite the space included between the last septum and the last but two. There is a little tendency to inflation of the body-chamber on the ventral side, and the aperture is bounded by a broad depression. It consists of a small opening on the ventral slope, a slightly contracted passage, and a large aperture, having its longer axis transverse and twice the length of the shorter; the apex of the shell lies between the centre of the large aperture and the middle of the passage. The surface is usually lost, but one other example than the type shows well-marked lines of growth—curving backwards on the ventral side—and most marked beneath the smaller aperture. The sutures are very slightly oblique on the side, going back towards the ventral line. The septa are distant from $\frac{1}{10}$ to $\frac{1}{12}$ the greatest transverse diameter apart. The last chamber is generally of half-size. The convexity of the septal surface seems to vary from $\frac{1}{6}$ the diameter downwards. The siphuncle is situated on the short diameter nearer the ventral side, from $\frac{1}{3}$ to $\frac{1}{4}$ the diameter from it. Its elements are bulbous, with a transverse diameter in the ratio

of 8 to 5 of the longitudinal. The shells presenting the above characters are usually of considerable size; namely, with a long diameter of about 3 inches.

Relations.—The uniformly elliptical shape of the shell with a transversely elliptic section is rare—few such being figured by Barrande; but it is difficult to see in what respect *G. ovum* differs from this. There is no difference to which I should attach specific importance if the specimens were found in this country. There cannot be any real confusion between this and *G. pyriforme*, which was different in both its sections.

Distribution.—In the Lower Ludlow of Leintwardine (9), of Ledbury (2), and of Herefordshire (1).

Gomphoceras pyriforme, Sowerby, Pl. XXII. figs. 2, 2*a*.

1838. Gomphoceras pyriforme, Sowerby in Murchison's 'Silur. System,' pl. 8, fig. 19 (upper).
1852. ,, ,, M'Coy, 'Palæozoic Fossils,' p. 322.
1873. Phragmoceras pyriforme, Salter, 'Cambrian and Silurian Fossils,' p. 174.

Type.—This specimen has obviously suffered contortion, and an examination of it alone would readily lead to the belief that it was only an inferior example of *G. ellipticum.* But other examples show that it is contorted from one less removed from its present shape. Its section is elliptic, the long diameter in the plane of symmetry. The dorsal side has a slight pretty uniform curvature, radius $5\frac{1}{3}$ inches, up to halfway through the body-chamber. It then makes a rapid curve to the large aperture. The ventral border is sigmoidal, being concave for the first $\frac{2}{3}$ of that part of the septal portion preserved and becoming convex, with radius 11 lines on the body-chamber. The rate of increase up to the middle of the latter is 1 in less than 2. The aperture is all broken; but the general direction is nearly horizontal, and the area occupies $\frac{2}{3}$ of the greatest breadth of the body-chamber. The septa are distant about $\frac{1}{11}$ of the diameter at the base of the body-chamber. The sutures are nearly direct. No siphuncle seen. Greatest length, $3\frac{3}{4}$ inches; greatest diameter, $2\frac{3}{4}$ inches. From the Lower Ludlow, Leintwardine. In the Collection of the Geological Society.

General Description.—The section in uncompressed specimens on the septal portion is not far from circular—at most the diameters are in the ratio of 8 to 7—the long diameter being in the plane of symmetry. The curvature gives a convexity on both sides, at least towards the upper part of the septate portion, the dorsal border having a mean radius of 5 inches, and the ventral one of $3\frac{1}{4}$ inches. Thus the great bulb of the type is due to compression. The rate of increase has a maximum of 1 in 2. There is a rapid curve on both sides to the aperture, the general direction of which has a very slight slope towards the ventral side, not

more than 12°. There is a slight constriction all round. The entire length occupies $\frac{3}{4}$ of the greatest diameter. The ventral aperture has a slope of 33°; it is rather quadrate, with a diameter $\frac{2}{3}$ that of the dorsal aperture. The latter is elongate in the antero-posterior direction, and not wider than the ventral; the passage is short and narrow and is the highest part of the shell. The septa have scarcely any convexity, and their distance is $\frac{1}{9}$ the greatest diameter apart. The last chamber, however, is half the ordinary depth, and the 3 before that are only equal to 2. The sutures are direct, and the siphuncle near the centre. The septa appear to have been weak and easily broken down, as they are scarcely indicated in a longitudinal section. The largest has a length of 4 inches, and a maximum diameter of $2\frac{2}{3}$ inches.

Relations.—A comparison of the characters of this species and of *G. ellipticum* can leave no doubt that they are very distinct, and that the type of the present is not contorted from the latter. It is far closer to *G. obovatum*, and difficult to distinguish when the part of the body-chamber containing the aperture is lost or distorted.

Distribution.—In the Lower Ludlow rocks of Leintwardine (4) and of Aymestry (1). These specimens show clearly the characters, but there are many fragments which might or might not belong to the same species.

The name has been used pretty indiscriminately for any *Gomphoceras*, and we thus find it recorded from the neighbourhood of Llandeilo and Woolhope and Malvern, by Prof. Phillips; from the Lower Ludlow of Dudley, by Garner; from the Wenlock Shale of Walsall, and the Wenlock Limestone of Dudley, by Salter; and in the Lower Ludlow of Coalbrookdale, by the same: but as it is impossible to be in all cases certain of the specimens referred to, it is doubtful if we can conclude more than that a *Gomphoceras*, something like this, occurs at these places. In the same way, some such species may be recorded from the Upper Ludlow of the Pentlands (2), where a form occurs with a central siphuncle and one side more convex than the other; also from the Wenlock Limestone or Shale at Dudley, contorted and showing only general shape (4).

Gomphoceras obovatum, Blake, Pl. XXII. figs. 3, 3*a*.

Type.—The section at the base of the body-chamber is uniformly elliptical; the axes being as 32 to 27, and the longer diameter is in the plane of symmetry. On the dorsal side the curvature is nearly uniform from the aperture to the earliest part preserved, with a mean radius of 3 inches; on the ventral side the septal portion is nearly straight, but the body-chamber rapidly bulges out so as to have a radius of curvature of only 14 lines. The mean rate of increase on the septal portion is 3 in 4. The body-chamber is $\frac{4}{5}$ the length of its greatest diameter at the base. The general slope of the aperture is 27°, and the total space occupied is equal to the length of the body-chamber. The ventral opening is elliptic, with diameters of 4″ and 10″, the

longest in the plane of symmetry. The dorsal aperture is fourfold; each lobe is rounded, the most dorsal pair the largest. The greatest transverse diameter of this aperture is 16 lines to a ventro-dorsal of 7 lines. The passage has a length of 14 lines, and is narrow. The highest point of the shell lies near the centre of the dorsal aperture. There are no ornaments remaining on the surface, but the last chamber has a series of crenulations of the usual character. The septa have very little convexity. They are $\frac{1}{9}$ the largest diameter apart, but the last is of half the usual size. The sutures have a very slight obliquity, rising to the dorsal side. The siphuncle is not accurately seen: probably it is central; but if not, it must be towards the ventral side. The greatest length is $4\frac{1}{2}$ inches, and the greatest diameter nearly 3 inches. From the Lower Ludlow of Ludlow. In the Ludlow Museum.

General Description.—It is in the type alone that the distinguishing characters presented by the aperture are seen. Other examples might have been referred to *G. pyriforme*, by allowing a little latitude to that species. The section of such is a little more elliptic, having the axes in the ratio of 4 to 3; also the rate of increase is more rapid, 2 in 3. The body-chamber has its greatest width in the middle of its length. The septal characters are as in the type. One example shows the crenulations on the last chamber. This is one of those species which, having one side far more convex than the other, one is tempted to call a *Phragmoceras,* but yet it is certainly a much closer approach to such a form as *G. ellipticum* than to *P. ventricosum*, the commonest types of the respective genera.

Relations.—The differences between this and *G. pyriforme* have already been indicated. Its nearest ally among Bohemian species is a small form called *Phragmoceras discrepans*; the general form and position of the aperture is very faithfully repeated in this, but it has only half the linear dimensions, besides which there are some minor points which give it a different aspect. In our species the body-chamber is broader compared to its length; the convexity on the ventral side is much greater, so that the smaller aperture is on the upward slope, and not on the ventral border, and the sutures are more curved. While, therefore, we may look on our species as the representative of the Bohemian, reaching a much finer growth, it seems worth while to signalise it by a special name. The name selected had been placed by Salter on the type specimen in the Ludlow Museum.

Distribution.—In the Lower Ludlow rocks of Ludlow (1) and Ledbury (2), and possibly also of Garcoed, Usk (1).

Gomphoceras eta, Blake, Pl. XXII. figs. 5, 5*a*.

Type.—The section is elliptic, the axes being at the maximum $23\frac{1}{2}$ lines and 21 lines, the longer in the plane of symmetry. The curvature on the dorsal side is uniform, the mean radius being $2\frac{1}{2}$ inches; on the ventral side the edge is nearly straight to the body-chamber, when it becomes of considerable convexity, of radius

2 inches. The greatest diameter is opposite the first $\frac{1}{3}$ of the body-chamber. The mean rate of increase of the long diameter up to this point is 2 in 3. The length of the body-chamber is $\frac{3}{4}$ of the long diameter of its base. The general direction of the apertures is horizontal, the surface on the dorsal side becoming quite horizontal before the large aperture is reached. The total space occupied by the aperture is about $\frac{2}{3}$ the diameter. The small aperture is a nearly equal axed but transverse ellipse facing horizontally; the large aperture is divided into two branches, which, with the passage, makes the figure of Y; the ends of the branches have little circular expansions. The passage and the branches are long and narrow and face upwards. The whole is well separated from the outside by an upward growth of the shell. The septa are nearly flat, and are distant $\frac{1}{11}$ the longest diameter apart; the last has half the usual size. The sutures are deeply impressed and direct. No siphuncle is seen. The length is $2\frac{2}{3}$ inches, the greatest diameter 2 inches. From the Lower Ludlow, Leintwardine. In the British Museum.

General Description.—Two other specimens showing a similar aperture are known, which agree in the general proportions and other characters, but are not in a condition to throw any further light on the species.

Relations.—The general shape of this species is singularly like that of *G. obovatum*, but the characters of the aperture immediately distinguish them. *Phragmoceras pavidum* (Barr.) has a similar aperture, but it is not horizontal, and the general curvature of the shell, especially on the ventral side, is much greater, so that it may really be a *Phragmoceras*. A somewhat similar aperture is seen in *Gomph. neglectum*, but the shape of the shell is different.

Distribution.—In the Lower Ludlow at Leintwardine (2) and at Usk (1).

Gomphoceras gratum, Barrande, Pl. XXIII. figs. 1, 2, 2*a*.

1865. Gomphoceras gratum, Barrande, 'Syst. Silur. de Bohême,' pl. 73, figs. 6, 7; pl. 82, figs. 13–16, p. 320.

Type.—Section oval, the narrower end on the ventral side, the axes in the ratio of 13 to 11; the longer one in the plane of symmetry. The general direction of the shell is straight, and its contours elliptical, the mean radius of curvature of both sides being 3 inches. The greatest thickness is at the base of the body-chamber. On the septal portion the rate of increase is 4 in 7. The body-chamber has a length equal to its basal diameter in the plane of symmetry. It does not contract so rapidly as the septal part, but continues of nearly the same diameter for some distance. The aperture is prominent, being produced and surrounded by a constriction. Its general direction is inclined 10° from the horizontal towards the ventral side, and it occupies $\frac{5}{6}$ of the greatest diameter.

The ventral opening is small, and transversely elliptical. The dorsal opening has three lobes on each side, increasing in size as we go from the ventral side; the dorsal boundary is concave. The passage is short and narrow. The dorsal opening faces upwards from the apex of the shell, but the ventral horizontally. The shell had lines of growth which made a pointed sinus backwards on the ventral side. The base of the body-chamber is crenulated. The septa have little convexity, and are distant $\frac{1}{10}$ the greatest diameter. The sutures are horizontal. The siphuncle is situated $\frac{1}{6}$ the diameter from the ventral side on the long diameter. Its diameter is $\frac{1}{6}$ that of the shell, and it is inflated between the septa. Greatest length, $2\frac{3}{4}$ inches; greatest diameter, $1\frac{1}{2}$ inches. From stage E, or Upper Silurian, of Bohemia.

General Description.—The British specimens which show the remarkable aperture of this species are but few in number. They are all more or less distorted by pressure. The section is probably nearly circular, and is made transverse or otherwise by compression, the diameters not being more unequal than as 11 to 10. The amount of curvature cannot be told, but it is about the same as in the type and nearly equal on both sides, the general direction being straight. The rate of increase is less than 2 in 3 on the septal portion. The body-chamber has a length of $\frac{3}{4}$ its greatest diameter at the base, and slowly decreases. The aperture, which is surrounded by a constriction, has suffered much and obvious distortion in every case, and the resulting forms have rather a different appearance, the shell in one (fig. 2) coming to a sharp point at the dorsal opening; in this case it shows three lobes on each side, increasing in size towards the dorsal side, but less unequal than in the type. The dorsal border is concave; the passage is short and narrow; the ventral opening is elliptic, with the long axis in the plane of symmetry, and is of fair size; it faces perpendicularly to the slope, which is now 30° from the horizontal. How much of this is due to distortion is not certain, but from another specimen, compressed on the side instead of drawn out, the ventral aperture makes but little show, and the lobes of the dorsal one are hard to make out, though present (fig. 1). The surface has fine lines of growth coming to a pointed apex on the ventral side, and the base of the body-chamber is crenulated. The septa have a convexity $\frac{1}{6}$ their diameter, and are distant $\frac{1}{13}$ the greatest diameter. The sutures are direct. The siphuncle is now unsymmetrically placed, nearly on the shorter diameter, at a distance equal to its own diameter from the ventral side; it is rather elliptic, with its longer diameter in the plane of symmetry. Greatest diameter, 22 lines.

There are thus several differences between our specimens and the type, which differences however are just in those characters that might be altered by distortion, while in all other points, especially in those independent of pressure, there is a remarkable agreement.

Relations.—Belonging to the series having a generally elliptic shape, and therefore easily confounded with *G. ellipticum*, the aperture separates it from this and all others, except *G. pollens* (Barr.), to which it is no doubt closely allied. That species, however, is characteristically ornamented with strong upward imbricating bands, of which there is no trace in our specimens.

Distribution.—In the Lower Ludlow of Leintwardine (2) and Usk (1).

GOMPHOCERAS CINCTUM, Blake, Pl. XXIII. figs. 5, 5*a*.

Type.—Section elliptic; diameters in the ratio of 16 to 13. General outline straight with little convexity, like two cones with their bases opposed. The septate portion increases in its long diameter at the rate of 1 in 2. The greatest thickness is at the last septum, from which the body-chamber contracts again at the rate of 2 in 3. There is a constriction at the base of the body-chamber and another round the aperture, which is not well shown, but the dorsal opening of which appears to have a simple elliptic outline. Septal characters not seen. Length, $2\frac{1}{4}$ inches; greatest diameter, $1\frac{1}{3}$ inches. From the Lower Ludlow rocks, Ludlow. In the British Museum.

General Description.—To an elliptic section and conoidal form, which it has in common with others, this unites a rapid tapering to a small apex. The aperture is not well preserved in most, but in one larger than usual the dorsal aperture is a transverse ellipse, and the ventral one is on the slope, elongated in the contrary direction, very much as in *G. ellipticum*. The constriction at the base of the body-chamber is seen in another example, and the same rate of increase in the earlier portion. The septa have little convexity, and are distant $\frac{1}{9}$ the greatest diameter apart, and the last has half the usual size. The siphuncle is not more than $\frac{1}{4}$ the diameter from the ventral side (fig. 6). The largest seen has a diameter of 2 inches.

Relations.—This species is near to *G. corona* by its general shape and flatness of the septa, and perhaps, also, the smallness of its aperture; but the tapering here is much more rapid. By its rapid decrease to the aperture it approaches *G. microstoma* (Barrande), but there is no reason to believe that the ellipticity of our species is due to compression, as they are found with the same characters in different localities.

Distribution.—In the Wenlock Limestone? Dudley (1), Ledbury (2), and Malvern (1); in the Lower Ludlow of Ludlow (1), Leintwardine (3), and Dudley (1).

GOMPHOCERAS NEGLECTUM, Blake, Pl. XXIII. fig. 3.

Type.—Section elliptic; the diameter in the ratio of 25 to 23; the long diameter in the plane of symmetry. The general shape is straight, there being an equal

convexity on both sides, with radius of curvature $2\frac{1}{2}$ inches; thus forming rather a butt-shaped shell, both ends being more or less truncate. The body-chamber does not commence till the contraction has set it; its length is $\frac{4}{5}$ of its basal long diameter. The aperture is produced, the shell having been thickened all round it. Its general direction is nearly horizontal, and it occupies nearly the whole of the upper surface. The ventral opening is round; the dorsal opening appears to consist of two nearly closed lobes of nearly the same size as the ventral opening, united to the passage, and thereby to one another, by narrower branches. The dorsal border is thus concave, and is $\frac{5}{6}$ as long as the ventro-dorsal axis of the aperture. The passage is rather long and narrow. The septa have a very slight convexity, and are more conical than spherical. They are distant $\frac{1}{11}$ the greatest diameter. The sutures are direct, and the siphuncle is central. Greatest length, 41 lines; greatest diameter, 25 lines. From the Lower Ludlow near Aymestry. In the Woodwardian Museum.

General Description.—Only one other specimen has been seen from the same locality, and this adds nothing to the type beyond confirming its principal characters.

Relations.—Even without the aperture the generally elliptic shape of the whole, combined with its central siphuncle, separates this species from *G. pyriforme* on the one hand, and *G. ellipticum* on the other. *G. eta* has an aperture of the same type, though with minor differences; but the shape of the shell is not the same. From *G. æquale* it is distinguished by its aperture. *G. Haueri* of Barrande is very close to this, but the dorsal lobes of the aperture are not expanded, and the septa have a considerable convexity, while the siphuncle is scarcely central.

Distribution.—In the Lower Ludlow rocks of Aymestry (2).

Gomphoceras amygdala, Barrande, Pl. XXV. figs. 4, 4*a*, 4*b*; Pl. XXIII. figs. 7, 7*a*.

1865. Gomphoceras amygdala, Barrande, 'Syst. Silur. de Bohême,' pl. 77, figs. 23–26; and pl. 80, figs. 1–17, p. 273.

Type.—The section varies from nearly circular, especially at the smaller end, to a transverse ellipse, with axes in the ratio of 5 to 6. The ventral side has more convexity than the dorsal. The rate of increase on the septal portion is at the rate of 1 in a little less than 3. The body-chamber does not decrease much; its length is about $\frac{3}{4}$ the basal diameter. The aperture has no very marked constriction round it; it occupies about $\frac{3}{4}$ the greatest diameter. The dorsal opening is a transverse rather quadrate ellipse, whose boundaries rather vary. The ventral opening and the passage are scarcely distinct, and have about the same width as the dorsal opening; the apex lies between the two. The septa have a convexity of $\frac{1}{5}$ their

diameter, and are at variable distances from $\frac{1}{5}$ to $\frac{1}{22}$ the same; in a specimen of circular section the distance is $\frac{1}{7}$. The siphuncle is situated from $\frac{1}{5}$ to $\frac{1}{6}$ of the diameter from the ventral edge, and consists of slightly inflated bulbs. Length, 3 inches; diameter, $1\frac{1}{2}$ inches. From stage E, or Upper Silurian.

General Description.—There is not an absolute agreement between our forms and the Bohemian, but the differences appear to be within the range of what may be called varietal. The section is circular, but there is rather more convexity on the ventral side. The rate of increase on the septal portion is at the rate of 1 in 3. The body-chamber is somewhat conical, and has a length of from $\frac{2}{3}$ to $\frac{4}{5}$ the greatest diameter in different examples. The aperture consists of a transversely elliptic dorsal opening, and a ventral opening and passage united, or slightly marked off, of the same diameter as the dorsal opening; the apex of the shell lies between the two parts of the aperture, which occupies $\frac{4}{7}$ of the largest diameter, and is scarcely marked off by any constriction. The septa have a convexity of rather more than $\frac{1}{5}$ the diameter, and are distant $\frac{1}{7}$ of the same; the siphuncle is situated near the ventral border, and is bulbous. Greatest diameter, $1\frac{1}{2}$ inches. An example figured (Pl. XXIII. fig. 7) shows rather a remarkable feature on the body-chamber. This is a pair of depressions radiating from the interval between the two parts of the aperture, but not joining the latter. They are long and narrow, but one is longer than the other; what may be their significance I cannot at present even guess.

Relations.—The typical Bohemian forms, with transversely elliptic section and siphuncle not lateral, approach by these characters and the form of the aperture very close to *G. ellipticum*; but the more inflated and rounded form of the latter seems sufficiently to distinguish them. Our English forms are certainly distinct and are more nearly allied to *G. crater*, which has, however, much greater septal convexity, and the aperture, though similar, is by no means identical.

Distribution.—In the Lower Ludlow of Ledbury (3, and 2 doubtful), and in the Wenlock Limestone of the same locality (1 doubtful).

Genus PHRAGMOCERAS.

PHRAGMOCERAS PRIUS, Blake, Pl. XXIV. fig. 5.

Type.—The section is elliptic, with the long axis in the plane of curvature. The ratio of the axes about 3 to 2. The mean radius of curvature $2\frac{1}{2}$ inches when the mean diameter is $1\frac{1}{4}$ inches. The rate of increase is 1 in 8, and this is continued on the body-chamber till the commencement of the aperture. In the transverse direction the body-chamber rapidly increases to the middle and then decreases again, so as to be bulging or oval. The dorsal aperture is elliptic, with the long axis in the plane of symmetry, and of small dimensions; the rest is not clearly

seen. The surface had only rough lines of growth. The septa have a convexity of $\frac{1}{6}$ their long diameter, and are distant $\frac{1}{8}$ the mean diameter. The sutures are slightly undulating, but on the whole direct. The siphuncle is not seen; but, the convexity having been cut and polished to find it, it is certainly not external. Length, $2\frac{1}{2}$ inches; greatest diameter, $1\frac{1}{3}$ inches. From the Bala Beds of Rhiwlas. In the Museum of Practical Geology.

General Description.—Another specimen from the same locality shows some contraction to the aperture, and may therefore belong to this species. Its general shape and rate of increase are the same, as also the septal characters; but its curvature is less, the mean radius being nearly 3 times the corresponding diameter.

Relations.—There is great similarity in appearance between this and *Cyrtoceras intermedium* of M'Coy; but this is an undoubted *Phragmoceras*, a fact of very considerable interest, as being only the second species recorded from the Lower Silurian of Europe, *P. rectiseptatum* of Römer being the other.

Distribution.—In the Bala Beds, Rhiwlas, Bala (2).

Phragmoceras ventricosum, Sowerby, Pl. XXIV. figs. 1, 1*a*, 2, 2*a*, 3.

1838. Phragmoceras ventricosum, Sowerby in Murchison's 'Silurian System,' pl. 10, figs. 4, 6 (not fig. 5).
1852. „ „ M'Coy, 'Palæozoic Fossils,' p. 322.

Type.—Section an elongated ellipse, the longer axis in the plane of curvature. Ratio of axes 2 to 1, which may be more or less due to pressure, as it is less on the septal portion. Mean radius of curvature about $3\frac{1}{2}$ inches, when the mean diameter is 3 inches. Rate of increase decreasing from 1 in 2 to 1 in 9. The body-chamber has a length equal to the longer diameter (now compressed) of its base. The aperture is nearly closed for some distance above the central line, but owing to compression the true shape of the opening cannot be seen. The shell has a uniform ornamentation of fine ribs about 10 per inch on the side, curving backwards and so convex towards the aperture; more irregular at last. The septal convexity is not great. The sutures are sigmoidal, curving back in the middle of the side, but on the whole direct, and about $\frac{1}{12}$ the diameter apart on the outside. The siphuncle is not seen with perfect distinctness, but appears to be internal and bulbous. Length, $6\frac{1}{4}$ inches; greatest diameter, $3\frac{1}{2}$ inches. Associated with this specimen is another, also figured by the author of the species, which has an irregular aperture in which the large opening is transverse, but not produced. From the Lower Ludlow of Aymestry. In the Museum of the Geological Society.

General Description.—The shells of the *Phragmocerata* seem to have been but weak ones, and they have accordingly given way under pressure to a very puzzling extent, and we have no very reliable determination of the true shape and

curvature of the shell or of the pattern of the aperture. In this species the section is an ellipse, with the long axis in the plane of curvature; but the ratio of the axes is very variable, from 2 to 1 down to 5 to 4. M'Coy, in his description of this species, states that the figures given by authors do not sufficiently indicate the flattening of the septate portion. It appears, however, that his specimen must have been peculiar; for in most, though not in all, it is the body-chamber that becomes most flattened, and the most nearly circular sections are found on the small ends. The curvature is about that of the type, and does not appear to vary greatly. The body-chamber varies in length from a little less to a little more than its basal long diameter. The aperture is more open in youth, and then consists of a large opening scarcely transverse, a small one of a quarter the linear dimensions, and a narrow passage (fig. 2*a*); later the two openings become more distinct (fig. 3), and, finally, the passage closes up irregularly (fig. 1), and the large opening grows transverse. The surface of the shell, however, is not produced in such as agree in other respects with the type. Hence Sowerby's fig. 5 must be excluded from the species. The ornaments are most marked on the convex side, where they form, in some, strong steps having an upward imbrication. In the body-chamber of some they degenerate into rugæ of growth with intermediate lines, but are never quite lost. They curve deeply backwards, and are on the average about 1 line apart. The septal convexity is from $\frac{1}{5}$ to $\frac{1}{6}$ the long diameter. The distance of the septa in quite a young form reaches as much as $\frac{4}{7}$ the corresponding diameter, but the true distance is from $\frac{1}{12}$ to $\frac{1}{14}$ in the middle of the side. They had but little strength, as they are utterly broken down in section. The sutures are essentially sigmoidal. The siphuncle is seen in several to be internal; it is elliptic in section, the long diameter in the plane of curvature reaching $\frac{1}{6}$ that of the septum. The type is one of the largest specimens known, but some have a diameter at the aperture of over 4 inches.

Relations.—The form corresponding to this in the Bohemian fauna is the *P. Broderipi*, which is there as widely spread as our own species is here. The resemblance is close; their genetic relationship cannot be doubted, but that species appears to be uniformly more curved than ours is; as to the large aperture being more rounded, I believe our species has not a very transverse opening, those specimens which should prove it either being distorted or belonging to another species. It is doubtful whether a slight increase of curvature ought to be sufficient to distinguish a species, but it is probably hopeless to attempt to suppress *P. Broderipi* as a name. From the other British *Phragmocerata* it differs in one case (*P. imbricatum*) by its ornaments, and in the other (*P. arcuatum*) by its non-produced aperture and closer sigmoidal septa.

Distribution.—In the Upper Llandovery rocks of May Hill (2); in the Wenlock Shale, Llandewi (1) and Ledbury (1); in the Wenlock Limestone of Dudley (4) and of Malvern (4); in the Lower Ludlow of Aymestry (2), of Ledbury (4), of

Mocktree (1), and Presteign (1); in the Aymestry Limestone of Dudley (5). It is also recorded by Garner from the Lower Ludlow of Dudley, and by Salter from the same beds at Coalbrookdale. The latter author, in the third volume of the 'Memoirs of the Geological Survey,' records it also from Caradoc; but though I have examined all the Palæozoic Cephalopoda in the Museum of Practical Geology, I have not seen any either so labelled or actually belonging to the species. I think, therefore, there must be some mistake on the point.

PHRAGMOCERAS IMBRICATUM, Barrande, Pl. XXV. figs. 2, 2*a*.

1865. PHRAGMOCERAS IMBRICATUM, Barrande, 'Syst. Silur. de Bohême,' pl. 46, 175, and 244, p. 212.

Type.—The section is elliptic, with the long axis in the plane of curvature. The diameters are in the ratio of 4 to 3. The curvature is considerable, the mean radius being $2\frac{1}{4}$ inches when the mean diameter is $1\frac{3}{4}$ inches. The rate of increase on the septate portion is 2 in 5, measured along the convexity. Examples have been found showing the initial cap with a central perforation and concentric striæ. The body-chamber has a length slightly greater than its basal diameter. It continues the convex curve without change, but is rather swollen on the concave side. The aperture consists of a large opening which is transversely elliptic, with axes in the ratio of 7 to 4,—it is somewhat produced outwards as well as forwards; of a passage which is closed in parts, and which forms nearly a flat surface between the two openings, not quite parallel to the base of the body-chamber, but rising towards the dorsal side; and of a small opening which is elliptic, with the long axis ventro-dorsal, and running out into a beak on the ventral side. The shell is thin and consists of lamellæ, which imbricate upwards, and cover the surface with delicate lines, which curve rapidly backwards on the sides, meet in a rounded curve on the convex side, and bend also back to meet on the concave side in a backward running tongue which lies in a median furrow. These lines are about $\frac{2}{3}$ of a line apart in the middle of the side. There are feeble crenulations at the base of the body-chamber. The septa have a convexity of $\frac{1}{8}$ their diameter, and are distant the same proportion. The sutures are nearly direct, and show very little concavity on the sides. The siphuncle is elliptic, bulbous, and internal, about $\frac{1}{8}$ the whole diameter in its long axis. Length, $3\frac{1}{2}$ inches; greatest diameter, 2 inches. From stage E, or Upper Silurian.

General Description.—The section of the British specimens, like that of the type, seems to vary independently of compression. It is elliptic, with the long axis in the plane of curvature, the ratio of the diameters varying from 4 to 3 up to 3 to 2, but in some they are more equal than in either of these ratios. The external curvature

is considerable, the mean radius being 2 inches when the mean diameter is $1\frac{1}{2}$ inches. The rate of increase on the septate portion is a little more than 2 in 5. The length of the body-chamber is uncertain, the septa mostly being covered. The curvature is continued without change to the aperture on both sides. The aperture consists of a large opening which is transverse, the diameters being as 3 to 2,—this projects both forwards and outwards; of a long passage which is quite closed and makes the upper surface nearly or quite flat; and of a small aperture of elliptic shape, with the long axis ventro-dorsal, more or less produced ventrically. The shell has upward imbricating lamellæ, running sigmoidally across the side, so as to come to a broad curve on the convex border, and on the concave border bending rapidly and suddenly back into a quadrate backward pointing tongue, which lies in a well-marked groove. These imbrications are but slightly elevated, and are distant about $\frac{1}{2}$ of a line. No crenulations have been seen at the base of the body-chamber. The septal and siphuncular characters are not very certain. The greatest length is 4 inches, and greatest diameter $2\frac{1}{2}$ inches.

Relations.—The greater curvature, more rapid increase, peculiar ornaments, and differences of septal character separate this species very clearly from *P. ventricosum.* It is much more nearly allied to *P. arcuatum.* Indeed, as the present species is nearly peculiar to the Wenlock Limestone, and the last named characterises the Ludlow Series, it seems probable that the one is the direct descendant of the other, having lost some of the peculiar characters. These are the regularity and fineness of the upward imbrications—their coming to a tongue-like curve on the concave side situated in a depression, the greater curvature and more rapid increase, and the outward direction of both apertures. In the other characters they show a singular agreement. The crenulations at the base of the body-chamber, which are so constant in *P. arcuatum,* have not been seen in British specimens of this species, though Barrande notices them in some from Bohemia.

Distribution.—In the Wenlock Limestone of Ledbury (8) and of Dudley (5), and possibly a fragment in the Lower Ludlow of Garcoed, Usk (1).

PHRAGMOCERAS OBLIQUUM, Blake, Pl. XXIV. fig. 7.

Type.—The section is oval, the larger end being toward the convex side, and the ratio of the axes being about 2 to 1. The rate of increase on the septal portion is not very great—about 1 in 3. The curvature has a mean radius of about $1\frac{1}{2}$ inches, which is greater than the diameter of the shell. The body-chamber continues the curve of the sides, but its length is less than its basal diameter. The line of aperture is oblique, about 40° with the base of the body-chamber. Both apertures are rather large and almost transverse, but are broken down. They are joined by a perfectly closed passage. No ornaments are seen. The greatest diameter is

$1\frac{1}{2}$ inches; the length is $2\frac{3}{4}$ inches. From the Wenlock Limestone, Dudley. In the Woodwardian Museum.

General Description and Relations.—This is a specimen which I cannot satisfactorily fix to any known species. It has the aperture of *O. imbricatum*, but not its shape of section or rate of increase; but the obliquity of the aperture is the distinguishing feature. No signs of ornament tempt us to place it with *P. ventricosum.*

Distribution.—In the Wenlock Limestone of Dudley (1), and possibly in the Lower Ludlow of Ledbury (1).

PHRAGMOCERAS SUBEXTERNUM, Blake, Pl. XXV. fig. 3.

Type.—Section elliptic, with the shorter axis in the plane of curvature, the ratio being 8 to 9. Curvature only perceptible on the convex side, the other side being nearly straight. The rate of increase is 2 in 5 on the septal portion. The body-chamber continues to increase till near the aperture, when the convex side turns round rapidly, so as to be within 45° of the horizontal; but the aperture is not seen. The ornaments consist of irregular rugosities sloping back to the convex side, covered by parallel lines of growth; the former about 20 per diameter. The septa have only a slight convexity; they may be very close, but their position is not certainly seen. The suture of the last slopes backwards towards the convex side parallel to the ornaments. The siphuncle is small, and situated $\frac{2}{5}$ of the diameter from the convex side. Greatest length, $3\frac{1}{4}$ inches; greatest diameter, $2\frac{1}{4}$ inches. From the Wenlock Limestone of Ledbury. In the collection of Dr. Grindrod.

General Description.—The type is unique.

Relations.—The extraordinary position of the siphuncle, either for a *Phragmoceras* or a *Gomphoceras*, renders few comparisons possible. The ornaments place it rather near to *G. imperiale*, but that has no curvature. One might also think of *Orthoceras Barrandei*, but that species seems to come to a termination without any ingrowth towards the aperture.

Distribution.—In the Wenlock Limestone of Ledbury (1).

PHRAGMOCERAS ARCUATUM, Sowerby, Pl. XXVI. figs. 1, 2, 2*a*, and Pl. XXV. fig. 1.

1838. PHRAGMOCERAS ARCUATUM, Sowerby in Murchison's 'Silurian System,' pl. 10, fig. 1A, p. 621, not var. *a* (includes *P. ventricosum*, fig. 5, but not figs. 4, 6).

Type.—This I have not been able to discover, but the figure given by Sowerby is fairly characteristic. Section unknown, apparently elliptic, with the longer axis in the plane of curvature, and axis not very unequal. The mean radius of external curvature is $1\frac{7}{8}$ inches, with a mean diameter of $1\frac{1}{2}$ inches. The rate of increase

seems to be constant up to the aperture, with a very slight expansion near the convex side. Hence this has been taken for a *Cyrtoceras*, but it appears to contract in the transverse diameter. The rate of increase is 1 in 3. The body-chamber has a length equal to its basal diameter. The aperture is constricted in the middle, and Sowerby says the "beak" is "direct"? The ornaments are sharply marked lines of growth. On the base of the body-chamber is a crenulated band. The septa have a very moderate convexity, and are distant $\frac{1}{7}$ the mean diameter, the last being of half size. The sutures are nearly straight, only slightly concave towards the aperture. The siphuncle is internal and its elements are bulbous, their diameter being $\frac{1}{6}$ of that of the septum. The length is $2\frac{3}{4}$ inches, and the greatest diameter is $1\frac{3}{4}$ inches. In the Lower Ludlow of Ludlow, or Ledbury.

General Description.—It is to a great extent by inference that this name is adopted, the original specimen being undiscoverable. It is unlikely so well-marked a shell should be unique, especially when it is said to be found at Ledbury, a locality so well worked by Dr. Grindrod; and there is a species occurring there agreeing with Sowerby's description and figures, and separable from *P. ventricosum.* For this (now better known) species we may adopt the name of *P. arcuatum.*

The section when best preserved is oval (Pl. XXVI. fig. 2*a*), with the longer axis in the plane of curvature, the wider side on the convexity of the shell, the greatest thickness being at $\frac{2}{5}$ of the diameter towards the outside. The ratio of the diameters is 11 to 8, but when flattened they are of course less equal. The mean radius of curvature is $2\frac{3}{4}$ inches when the mean diameter is $2\frac{1}{4}$ inches. The rate of increase remains the same throughout in the ventro-dorsal plane, but transversely the body-chamber draws in to the aperture; the rate is 1 in $3\frac{1}{2}$ measured along the convex curve. The body-chamber has a less length than its basal diameter, but not far removed from it. The aperture consists of a large opening which is transversely uniform, and is situated on a prolongation of the shell, which closes in more ventrally, but continues its normal curvature here; of the passage which is closed pretty accurately for nearly 3 times the ventro-dorsal length of the large opening, and is parallel to the base of the body-chamber; and of the small opening which is produced horizontally and so becomes subtriangular. The ornaments of the shell are rough risings of growth which are easily lost, are not very regular, but which curve back very much towards the convex side, cutting the septa at an angle of 60°. On the base of the body-chamber in all specimens seen is a crenulated band, which is more or less feebly continued upon the lower part of the body-chamber. As a rule, I am not inclined to consider these marks as a specific character, for they may be absent or present; but in this species their presence seems always accompanied by the other distinctive characters, and I have not yet observed them in specimens certainly belonging to *P. ventricosum.* The septa are direct, with very little concavity of suture; their convexity is $\frac{1}{9}$ the long diameter, and their distance $\frac{1}{7}$, or,

by compression, $\frac{1}{9}$ of the same; the last one in some half the usual size. The siphuncle is internal and bulbous; the bulbs are elliptic; the long diameter in the plane of curvature reaching to $\frac{1}{6}$ the whole diameter. The greatest diameter is 4 inches.

Relations.—Although the only indication of the aperture given by Sowerby is that the "beak" is "direct," which it certainly is in the specimens seen, the coincidences in other respects will be seen to be too remarkable to leave much doubt that we have here the true *P. arcuatum.* It differs from *P. ventricosum* in its greater curvature; in the prominence and shape of its larger aperture; in the character of the ornaments, and perhaps in the crenulation of the base of the body-chamber; in its straighter and more distant septa. The specimen figured by Sowerby (fig. 5), as belonging to his *P. ventricosum*, shows the produced aperture and the irregularity of the ribbing, and so belongs here. From *P. imbricatum* this species differs in the character of its ornaments and its general shape. Barrande has compared *P. arcuatum* with *Cyrtoceras Murchisoni*; but if my interpretation be right, the latter can have no relation to it unless it be a *Phragmoceras*. The real Bohemian representative is *P. comes*, of a little later date. It has not been so compressed as ours; but with a little squeezing there would be nothing to choose between them, but *P. comes* shows no crenulations at the base of the body-chamber.

Distribution.—In the Wenlock Limestone of Dudley (3); in the Lower Ludlow of Ledbury (8) and of Mocktree (1).

Phragmoceras externum, Blake, Pl. XXVI. fig. 3.

Type.—Section rather roundly triangular than circular; axes unequal, the shorter axis being in the plane of curvature in the ratio of 14 to 15. The angle of the triangle towards the outside curvature slight. The rate of increase on the septate portion is a little less than 1 in 2. The shell begins to contract before the last chambers, but the aperture is lost; no ornaments are seen. The septa are very nearly flat, and are distant $\frac{1}{8}$ the mean diameter. The sutures slope a little backwards towards the convex side. The siphuncle is external, situated in the angle of the triangular section, and has a sub-elliptic shape. Greatest length, $2\frac{1}{2}$, inches; greatest diameter, $1\frac{1}{4}$ inches. From the Lower Ludlow of Ledbury. In the collection of Dr. Grindrod.

General Description.—The type is unique.

Relations.—The contraction of the body-chamber renders it highly probable that this is a *Phragmoceras* and not a *Cyrtoceras*, allied by its external siphuncle to *P. devonicans*, Barrande; but that is altogether too large a shell: no *Cyrtoceras* is near enough to it for comparison.

Distribution.—In the Lower Ludlow of Ledbury (1).

Genus ASCOCERAS.

ASCOCERAS BARRANDEI, Salter, Pl. XXVI. fig. 9.

1858. ASCOCERAS BARRANDEI, Salter, 'Quart. Journ. Geol. Soc.' vol. xiv. pl. 12, fig. 7, p. 180.
1867. " " Salter in Murchison's 'Siluria,' Foss. gr. 63.

Type.—Section at the base of the body-chamber, now much compressed, so that the long diameter in the plane of symmetry is in the ratio of 5 to 2 to the short one. The radius of curvature is about $1\frac{1}{4}$ inches at first. The whole body-chamber has a length, as preserved, equal twice its greatest breadth. The aperture appears simple, and has a diameter $\frac{4}{7}$ the greatest breadth. The ornaments are acute, separate riblets, as direct to the general direction as may be, varying in distance from 6 per line at the base to 14 per line near the aperture. The ordinary septa have a convexity of $\frac{1}{4}$ the long diameter. The sutures are straight, but oblique to the general direction of shell, slanting back to the convex side. The siphuncle is moderately large, and is situated $\frac{1}{3}$ the diameter from the convex side. The sigmoid septa are not more than two in number, and their curvature is not great, as they make an acute angle with the part of the shell above them on the concave side. The second succeeds the first in a nearly horizontal direction. They occupy a length of $\frac{9}{10}$ the whole chamber. Length, $2\frac{1}{4}$ inches; greatest breadth, 1 inch. From the Upper Ludlow, Stansbatch, Hereford. In the Museum of Practical Geology.

General Description.—The four examples referred to this species all agree closely with the above, in the general shape of section, the amount of curvature, and the proportion of length to the breadth. In one is a slight depression round the aperture. The ornaments vary in number, and their direction is seen to be of no consequence, as they become more nearly direct on approaching the aperture. In one example also, there is a line of fracture on the two sides of which the riblets have a different direction, showing that the animal had the power of repairing its shell; over the surface are seen some transverse epidermids. Not more than one sigmoid septum is seen in any other example; it has the same greatly curved outline cutting the less convex side at an acute angle at the top.

Relations.—When Salter wrote his description of this species, he had only Barrande's figure of *A. bohemicum,* which was published in the Bulletin of the Geological Society of France, to compare it with—the grand collection of plates belonging to the 'Système Silurien de Bohême' not having been published. He was thus led to state that it was a larger and thicker species than *A. bohemicum,* that the lines of growth were more oblique, and the septa more extravagantly

sigmoidal in outline. But, in fact, no specimen of the present species has been found of anything like the dimensions of the Bohemian form, and the obliquity of the lines of growth is well matched in the latter. The statement that the septa are more sigmoidal in outline I cannot understand, as the sole valid reason for separating the two species is that the septa in the present are but two in number, and they have nothing like so great a curvature. I can only account for the statement on the supposition that Salter included with his species a specimen which, on the very account of its more sigmoid septa, I refer to *A. bohemicum*, but which in this respect agrees neither with Salter's figure nor with the other specimens to which he refers. Our species may very well be the *Ascoceras Norvegicum* of Barrande, which also has but two sigmoid septa, not very greatly curved, but that appears to be fragmentary and is not figured, and in any case Salter's is the older name.

Distribution.—In the Upper Ludlow, Stansbatch (1) and Ludlow (3). Salter mentions one from Hale's End, Malvern.

Ascoceras bohemicum, Barrande, Pl. XXVI. figs. 10, 10*a*, 10*b*.

1855.	Ascoceras bohemicum,		Barrande, 'Bull. Soc. Géol. de France,' vol. xii. pl. v. figs. 20–28, p. 74.
1865.	„	„	Barrande, 'Syst. Silur. de Bohême,' pl. 93, pl. 94, figs. 28–37, pl. 96, figs. 46–49, p. 354.
1877.	„	„	Barrande, loc. cit., pl. 494, figs. 14, 15, pl. 513, figs. 14–16, p. 97.

Type.—Section oval, the long axis in the plane of symmetry in the ratio of 5 to 4, the narrower end being on the convex side. The radius of curvature of the convex side of a large specimen is $3\frac{3}{4}$ inches, or nearly double the greatest breadth. The total length is $2\frac{3}{4}$ times the breadth; the aperture is on a produced cylindrical part, and is half the greatest diameter in breadth. The ornaments are fine riblets, about 6 per line, rather varying in direction, but on the whole transverse to the general direction of the shell; there are also in well-preserved young shells some longitudinal lines crossing them, and each riblet has finer parallel striæ. The septa have a convexity of $\frac{1}{4}$ their long diameter, and slope back with a straight suture towards the convex side. The siphuncle is moderately large, is situated near the convex side, and is surrounded on the septal surface by an elliptic depression. A longitudinal section (pl. 513) shows the true nature of the sigmoid septa admirably: the siphuncle rapidly diminishes in size and at the same time approaches the convex border, and the back-curved necks of the siphonal portions of the sigmoid septa are well seen; and these portions are proved to unite into one plate, from which the first sigmoid septum is continued. The sigmoid septa are 4 or 5 in number, and curve round so as to meet the exterior in an obtuse or at least a right angle. They succeed one another in a general vertical direction, and occupy all but the neck, in

the length of the shell. Greatest length, $4\frac{3}{4}$ inches; greatest diameter, nearly 2 inches. From stage E or Upper Silurian of Bohemia.

General Description.—Only one British specimen showing similar characters has been seen, and that is but a fragment. Its section is a uniform ellipse, with the axes nearly in the ratio of 2 to 1, although from the hardness of the matrix it does not appear to have been compressed. The ornaments are fine transverse riblets, about 7 per line. The septa have a convexity of $\frac{1}{3}$ their diameter, and slope back to the convex side (the specimen being only half preserved, the other side alone is seen); siphuncle $\frac{1}{3}$ the diameter from the convex side; sigmoid septa at least four in number: they make very sigmoid curves so as to cut the opposite side at an obtuse angle, and they succeed each other vertically. One of the surfaces seen at the end (fig. 10*a*) is convex from back to front, and concave from side to side.

Relations.—It may well be doubted if our British specimen is indeed *A. bohemicum*,—its section is different, and the septal convexity is greater; but as these differences may arise from compression, there are no ample grounds for their separation.

Distribution.—In the Upper Ludlow of Whitecliffe, Ludlow (1).

ASCOCERAS VERMIFORME, Blake, Pl. XXVI. fig. 8.

Type.—The section is not seen, the curvature is very slight, the radius being about 4 times the greatest breadth. The length is about the same multiple of it; the aperture is more than $\frac{3}{4}$ of the same. The ornaments are slightly undulating, nearly direct, upward imbrications, about 6 per line. The septal characters are not well seen, and no siphuncle is visible; the sigmoid septa are also obscure,—there do not appear to be more than two, and these, if really present, are only slightly sigmoid. Greatest length, 14 lines; greatest breadth, 4 lines. From the Lower Ludlow of Ledbury. In the collection of Dr. Grindrod.

General Description.—Another specimen of this species, which is the one to which the above-adopted name was applied, in the Museum of Practical Geology, by Salter, shows the same proportionate dimensions, curvature, and ornaments, and indicates that the second sigmoid septum was nearly parallel to the convex border, meeting the opposite side at an acute angle. This specimen is nearly 2 inches long.

Relations.—By the formation of its sigmoid septa, this is more nearly allied to *A. Barrandei* than to *A. bohemicum*, but differs from both in being so much narrower in proportion. The Bohemian forms that have the same shape appear to be either smooth or strongly ribbed.

Distribution.—In the Lower Ludlow of Ledbury (1) and in the Upper Ludlow of Ludlow (1).

Group III. Spirales.

Genus Nautilus.

Nautilus bohemicus, Barrande, Pl. XXVII. figs. 1, 2.

1865. Nautilus bohemicus, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 32, 33, &c.
Syn. 1838. Lituites Biddulphii, Sowerby in Murchison's 'Silurian System,' pl. 11, fig. 8.
1865. Nautilus tyrannus, Barrande, loc. cit., plates 38, 39, 40.
1865. Exosiphonites Edgellii, Salter, 'Cat. Foss. Mus. Pract. Geol.' (name only).

Type.—The figures given by Barrande of the two species quoted above show that some variation must be allowed in the dimensions, and I am constrained to regard the whole series as forming but one species. Certainly the fragmentary English specimens might equally well be referred to one or to the other. The rate of increase is given by the author as 2 for the first, and 1.75 for the second; but the figures show a variation between 1.8 and 2.5 for the first, and 1.8 and 2.1 for the second. The breadth of the last whorl varies in the one case from .42 to .56, and in the other from .47 to .5; the greatest difference being in the larger examples. The section is an elongated oval, rather flat on the sides and back; the greatest thickness, which is near the umbilicus, is said by Barrande to be $\frac{1}{2}$ the breadth, but none of the figures indicate it so small. The surface shows only backward-curving lines of growth, forming a sinus on the convex side. The body-chamber is less than $\frac{1}{2}$ a whorl. The aperture is simple and parallel to the lines of growth. The septa are about $\frac{1}{6}$ to $\frac{1}{8}$ the diameter of the whorl apart, and from $\frac{1}{3}$ to $\frac{1}{4}$ convex. The sutures are concave on the sides, and bend forward on the front. The siphuncle is a little beyond the centre towards the outside.

General Description.—Only fragments have as yet been found, but these are highly characteristic. The dimensions, however, are not satisfactorily ascertainable, but the shape of the figured specimen, as well as its size, agrees almost exactly with the drawing given by Barrande on his plate 40, referred to a large *N. tyrannus*. The whorls slightly overlapped, as shown by the concavity of the inside of the section. The section is elongate, roundedly subquadrate, with a thickness about $\frac{2}{3}$ the breadth. The ornaments are no more than lines of growth, sometimes pretty regular; they curve rapidly backwards so as to come to a sinus on the convex side; on what is probably an inner layer, these are found more crowded, upstanding and crinkled. Some have abundant transverse epidermids on the cast, viz. on the inner side of a body-chamber, 12 per line, but one specimen shows some in a longitudinal direction. The body-chamber extends to nearly

$\frac{1}{2}$ a whorl at least, and remains in contact with the inner whorls, while the outer curve loses some of its curvature, so that the surface spreads out radially; it does not at all contract in the perpendicular direction, but, if anything, expands. There is a thickening of the shell near the aperture. The septa are fairly convex transversely; the sutures are much curved forward on the outside. The small inner lobe noticed in recent and several extinct *Nautili* is well shown. The distance of the septa greatly varies, being from $\frac{1}{6}$ to $\frac{1}{9}$ the diameter of the whorl. The siphuncle lies a little beyond the centre towards the outside, and is of moderate size. In some examples, apparently of this species, no siphuncle can be seen in this position, or indeed in any other; but elsewhere they are broken down. The supposed external siphuncle of Salter is a shell lodged in the body-chamber.

Relations.—This appears to be the central figure of the group whenever representatives of it occur. Perhaps the name *Nautilus Biddulphii* ought to be adopted; but Sowerby's description is not sufficient for identification.

Distribution.—In the Wenlock Beds of Dudley (1) and Malvern (1); in the Lower Ludlow of Ledbury (11) and of Ludlow (1). Sowerby's *Lituites Biddulphii* was from Wenlock Limestone, Ledbury.

NAUTILUS HOLTIANUS, Blake, Pl. XXVIII. fig. 1.

Syn. 1865. LITUITES HOLTIANUS, Salter, 'Cat. of Mus. Pract. Geol.' (name only).
1868. „ „ Bigsby, 'Thesaur. Silur.' (name only).

Type.—The rate of increase is 2.5, and the last whorl is .5 of the whole. The section is rounded sagittate, being very flat on the sides, and narrow on the convex border, the greatest thickness being near the inside, but the amount is not measurable. Almost the whole surface exposed is smooth, but on the earlier part of the last whorl are some fine radial lines, and the inner whorls are not properly preserved. The body-chamber extends for nearly $\frac{1}{2}$ a whorl, but shows no change at the aperture. The septa are uniformly curved throughout, and are distant about $\frac{1}{4}$ of the diameter of the whorl, where seen. No siphuncle is exposed. The greatest diameter is $6\frac{1}{2}$ inches. From the Lower Ludlow of Ledbury. In the collection of Dr. Grindrod.

General Description.—The rate of increase and breadth of the last whorl vary very little in the different examples; the greatest breadth is .54. The section may be more or less due to compression, as all examples are more or less imbedded in the stone. The shape is always as in the type in adult forms, but more quadrate in the young, the maximum thickness observed being $\frac{1}{2}$ the breadth. On the outer whorl of some are seen slight undulations of growth towards the inner side, and a few

backward-curving lines; on the inner whorls there are about 40 gently backward-curving feeble ribs. The surface is also covered by very fine riblets, 11 per line, and by transverse epidermids in some specimens. The body-chamber has a slight tendency to leave the coiled portion, and reaches on the average about $\frac{1}{3}$ of a whorl. The inner side of the aperture is slightly produced, and the middle has a forward curve, and in some there is a slight constriction there. The septa are from 20 to 34 per whorl; fewer at first, but increasing in number continually; not very convex in the suture, but curving forward very rapidly both inside and outside, making almost a funnel-shaped lobe at the former place. The siphuncle is not accurately determined in any, but one example had some indications of an internal siphuncle, but in another it looks more probably central.

Relations.—The great proportionate breadth of the outer whorl distinguishes this from *N. bohemicus.* It is quite symmetrical, and is therefore not a *Trochoceras*, though its young form might have some resemblance to *T. cornu-arietis.*

Distribution.—In the Lower Ludlow rocks at Stokesay (4) and Ledbury (10).

Nautilus quadrans, Blake, Pl. XXX. fig. 1.

Type.—The rate of increase is 1.7, and last whorl .36 of the diameter. There is no sign of asymmetry. The section is subquadrate, rounded on the front, rather flat on the sides, and rounding gently on the inner side. The body-chamber is slightly produced beyond the curved part. Ratio of thickness to breadth as 9 to 10. On the earlier whorls there are backward-curving ribs with parallel riblets; these die off and leave the outer whorl smooth till near the aperture, where there are backward-curving undulations. The aperture has a very prominent and rounded inner edge, produced beyond the rest. The septa are about 50 per whorl; their convexity is slight in a transverse direction. No siphuncle is seen. The whole is covered with transverse epidermids. Diameter about 3 inches. From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.

General Description.—The other specimens agree in the general dimensions and the shape of the section with the type. The whorls are always just in contact; there is no sign in any of asymmetry, but the last chamber leaves the whorls for $1\frac{1}{2}$ inches in one specimen. The septa may be as many as 60 per whorl, and are moderately concave. The siphuncle appears to be sub-central and moderate in size. The outer whorls are always smooth, except for backward lines of growth, but the inner ones when seen have feeble backward-curving numerous ribs. Most specimens are crowded with transverse epidermids.

Relations.—If this be truly a *Nautilus*, it differs from *N. bohemicus* in its more open whorls, and its more quadrate section. There is no elongated straight portion

that should make it a *Lituites*; nor is there any sign of asymmetry that should place it in *Trochoceras*.

Distribution.—In the Wenlock Shale, Usk (3), Dudley (1), and in the Wenlock Limestone of Ledbury (1) and Dudley (3); in the Lower Ludlow, Ledbury (2); also in the Upper Ludlow, Presteign?

Subgenus TROCHOLITES.

NAUTILUS (TROCHOLITES) ANGUIFORMIS, Salter, Pl. XXVIII. figs. 2, 2*a*.

1855. LITUITES ANGUIFORMIS, Salter in Appendix to 'Palæozoic Fossils,' pl. 1L, fig. 26, p. viii.
1855. TROCHOLITES ANGUIFORMIS, M'Coy, 'Pal. Foss.' p. 323.

Type.—Rate of increase 1.46. Last whorl .29. Thus the whorls are scarcely in contact according to this measure, but the shell having gone they may have touched when it was present. The specimen is also somewhat compressed. The section is elliptic, with the long diameter in the plane of curvature, *i.e.* the whorl-breadth is greater than the thickness. About 3 whorls are seen, and there was possibly an initial vacuity. No ornaments beyond very feeble lines of growth. There are no signs of any change of shape or curvature in the body-chamber. The septa make a curve which is concave forwards on the side, and another shallower on the front, with a low convex curve between. In the inner whorls they are $\frac{1}{2}$ the whorl-breadth apart, and have the curves less marked, but they become closer, up to $\frac{2}{5}$ the whorl-breadth, at last. The septal surface has considerable convexity. The siphuncle is internal, of small size, on a prominence of the septal surface, as seen from behind. From the Bala Limestone, Llangollen. In the Woodwardian Museum.

General Description and Relations.—No other example has been seen.

NAUTILUS (TROCHOLITES) PLANORBIFORMIS, Conrad, Pl. XXIX. figs. 8, 8*a*, 9, 9*a*.

1847. TROCHOLITES PLANORBIFORMIS, Conrad, 'Journ. Acad. Nat. Sc. Philadelphia,' vol. viii. p. 274, pl. 17, fig. 1.
1848. " " Hall, 'Pal. New York,' vol. i. p. 310, pl. 84, fig. 3.
1852. " " M'Coy, 'Palæozoic Fossils,' p. 324.
1852. " " Salter, Appendix A to 'Palæozoic Fossils,' p. 8.
1866. LITUITES PLANORBIFORMIS, Salter, 'Mem. Geol. Surv.,' vol. iii. p. 358, pl. 25, fig. 5.
1873. " " Salter, 'Cambrian and Silurian Fossils,' p. 71.
Syn. 1845. NAUTILUS PRIMÆVUS, Salter in Sedgwick, 'Quart. Journ. Geol. Soc.' vol. i. p. 20 (name only).
1852. LITUITES HIBERNICUS, Salter, 'Brit. Assoc. Rep.' p. 61.

Type.—The example figured by Hall shows a rate of increase of about 1.4, and the last whorl .34, but the figure is variable in this respect. There is no want of

symmetry. The section is transverse in the ratio of 11 to 6, reniform in shape by the overlapping of the previous whorls. The surface has obliquely-marked ridges, curving backwards in a sinus on the front. There are lines of growth parallel to these and longitudinal striations, according to Conrad, which, however, have not been observed by Hall. The specimens are from the Hudson River group.

General Description.—A single small fragment has formed the subject of all the above English references, except an allusion by Salter to there being better specimens, the descriptions being adopted from Hall. This specimen shows no external ornaments, but has a well-marked constriction on its surface, which forms a sinus on the convex side. The siphuncle is internal, and the convexity of the septum moderate. The section is transverse, reniform, and nearly twice as thick as it is broad. The shape of the suture on the front is not seen, nor is it stated by Hall. An admirable small specimen from the Lower Llandovery of Golengoed, marked as *Lituites undosus* in the Catalogue of the Museum of Practical Geology (fig. 7), shows $2\frac{1}{2}$ whorls, of reniform section. The measures agree generally with the above. The surface has low, irregularly striated ribs, as numerous as the septa, curving gently backwards till near the convex side, where they make a deep sinus, cutting 3 septa; these ornaments are quite superficial, and leave the cast smooth. The siphuncle is conspicuous and internal. The septa are 33 in number in the last whorl, and have a backward wave on the flattish front. Other specimens are external casts only: one reaches a diameter of $3\frac{1}{2}$ inches, and seems to be more evolute; another shows beautiful epidermids, curving backwards and passing straight across the front.

The specimen to which the name *Lituites Hibernicus* has been applied (fig. 8) agrees with the rest in its general aspects. It has a ratio of increase 1.33 and the last whorl .33, the inner whorls being somewhat concealed. The only difference indicated by Salter is that the sutures have a sinus on the front. The lines taken for sutures in the specimen may more probably be impressed lines of growth, as shown by other examples, for they cannot be traced all round the whorl, and, even if they were septa, the specimen would still remain within the limits of the species. This specimen shows the form of the aperture, which is bounded behind by a constriction and then has an outward-turned lip.

Varieties.—An example associated with the others from the Bala Beds, in the Museum of Practical Geology, has so different a shape of section that it must be, at least, reckoned as variety *trapezoidalis* if it is not worthy of a specific name. The section is very flat on the front, and somewhat so on the sides, with no indentation within. It is transverse in the ratio only of 10 to 9.

Relations.—This differs from *Trocholites anguiformis* by the much more transverse section, and agrees very well with the American species to which it has been referred.

Distribution.—In the Bala Beds, Cymmerig Brook (2), Glyn Ceiriog (6), including the variety *trapezoidalis*, Twll Ddu (1), Kildare (1) (the *L. Hibernicus*); also Lower Llandovery, Golengoed (1).

NAUTILUS (TROCHOLITES) SCOTICUS, Blake, Pl. XXIX. fig. 6, and Pl. XXVIII. fig. 4.

Type.—Rate of increase 1.45. Last whorl .37; the outer whorls slightly overlapping. The specimen is contorted, and thus appears out of symmetry. The section is a nearly uniform ellipse, with axes in the ratio of 10 : 9, and the long diameter in the plane of curvature. There are no ribs of large size, but the whole is uniformly covered by sharp riblets, which pass obliquely backwards and meet at a rounded angle of 60° on the front. There are about 3 of these per line in the middle of the whorl. The body-chamber leaves the coiled portion for a short distance, and the shell is thickened near the aperture, which is parallel to the riblets: thus it is oblique, and has a deep concavity on the front and then the shell expands. No septal characters are ascertainable—though septa are present. From the Bala Series, Penwhapple Glen. In the Museum of Practical Geology.

General Description.—Only one other example (Pl. XXVIII. fig. 4) can be referred to this. It shows the centre to have had no vacuity, and the shell to have $2\frac{1}{2}$ whorls in a diameter of $\frac{3}{4}$ inch. There are the fine ornaments as before, and the septa grow closer towards the larger end. On the average there are about 22 per whorl, and they are uniformly concave. No siphuncle has been seen.

Relations.—This specimen has been labelled *Lituites cornu-arietis* in the Museum of Practical Geology, as the nearest ally to it among named forms. It differs, however, in the absence of the large ribs. It is so like the general shape of *Trocholites planorbiformis* that I cannot doubt its belonging to the same genus.

Distribution.—In the Bala Series, Penwhapple Glen, Ayrshire (1); and in the Upper Llandovery, Bogmine, Shelve.

GROUP IV. IRREGULARES.

Genus TROCHOCERAS.

TROCHOCERAS REMOTUM, Blake.

Type.—The only specimen seen has its characters much concealed by an encrusting material, which may be organic and spongeous. The rate of increase is about 1.43, and the last whorl is .3 of the diameter. The whorls are only just, if at all, in contact. There is no proof of its having been elevated, and therefore its reference to the genus *Trochoceras* is doubtful. It is only placed there on account

of its general shape and the position of its siphuncle. The section has flattish sides and a round front. If ever there were any ornaments, they are now utterly obscured. The septa are a little undulating, and distant less than $1\frac{1}{5}$ the whorl-breadth. The siphuncle is external. Diameter about 5 inches.

Relations.—This has the proportions and absence of ornament of *T. speciosum*, but the section is flatter and the septa more remote and undulating.

Distribution.—This specimen is from the Durness Limestone in Sutherlandshire, which is on the horizon of the Lower Llandeilo. It was collected by Mr. C. W. Peach, who informs me that he has seen some *in situ* of more than 6 inches in diameter. The characters are so obscure, that from any other locality it would scarcely be worth notice, but the presence of a *Trochoceras* or *Lituites* of any kind in these early rocks is an important and interesting fact.

Trochoceras (?) cinereum, Blake, Pl. XX. fig. 2.

1843. Phragmoceras compressum, Portlock, 'Geol. Report,' pl. 28b, fig. 2, p. 282.
Not Phragmoceras compressum of Sowerby.

Type.—The whorl is not complete, but the species appears to be a *Trochoceras*, by its great curvature and its want of symmetry. The rate of increase is great, and the last whorl is equal to or greater than $\frac{1}{2}$ the diameter. The section is oval, the greatest thickness being near the outside—approximately the thickness is $\frac{1}{2}$ the breadth—but it may have been compressed. The surface shows very peculiar ornaments. They are fine clearly drawn alternate riblets and striæ of equal size, from 3 to 4 per line, which start out straight from the inner edge of the whorl for a little way, then bend backwards very rapidly and become almost longitudinal, and finally bend out again to pass straight over the back at a point nearly as far behind the inside edge as the breadth of the whorl. Towards the aperture the curve becomes convex forward before the backward turn is taken, which is thus reduced in length. The aperture is parallel to these lines and is not contracted. These lines are not, however, simply lines of growth, they are ornaments. The septa are pretty convex, and separate about $\frac{1}{10}$ the diameter. The sutures are nearly direct. No siphuncle is seen. Diameter about 4 inches. From a light ashy bed, referred to the Bala Series at Desertcreat. In the Museum of Practical Geology.

General Description.—Two other examples only of this very curious form have been seen from the same locality. They both show the same general shape, and the peculiar sigmoid ruled lines upon the surface, which however die away in parts. One of these is the figured specimen, in which the want of symmetry is not well marked, neither is the completion of a whorl. The others, those less figurable, are more decisive on these points.

Relations.—The dimensions as well as the ornaments clearly distinguish this from *Cyrtoceras compressum*, though possibly that species is its nearest ally among the forms that had been described in Portlock's time.

Distribution.—Found only in Bala Beds at Desertcreat (3). The matrix is a peculiar light porous brown rock, which looks very much like volcanic ash, whence the name has been suggested.

TROCHOCERAS CORNU-ARIETIS, Sowerby, Pl. XXI. figs. 6, 6*a*; Pl. XXVIII. fig. 5.

1839. LITUITES CORNU-ARIETIS, Sowerby in Murchison's 'Sil. Syst.' pl. 20, fig. 20, p. 643 (both varieties).
1843. „ „ Portlock, 'Geological Report,' pl. 28B, fig. 7.
1849. LITUITES SOWERBIANUS, D'Orbigny, 'Prodrome,' p. 1.
1852. LITUITES CORNU-ARIETIS, M'Coy, 'Palæozoic Fossils,' p. 323.
1852. „ „ Salter, Appendix to 'Pal. Fossils,' p. viii.

Type.—There are two so-called varieties of this species, according to Sowerby, and they have apparently somewhat different characters. In the example, var. α, which is merely an external cast, the rate of increase is 1.42, last whorl .33 of the diameter. The several whorls are just in contact, all exposed, fitting closely to the centre, and not quite symmetrical; they are 3 in number, and there is no straight portion. Section apparently rounded; thickness $\frac{7}{10}$ the whorl-breadth. The ribs are backward curving, not clearly separate, becoming wider apart with age, and covered by parallel riblets. Diameter 16 lines. From Caradoc Sandstone, Corton, near Presteign. In the other example, var. β, the rate of increase is only 1.2, and the last whorl .3 of the whole, so that the inner whorls are partially concealed. It is now compressed, and thus has an acute front, but the sides are uniformly convex. The ribs are sharp, and about 27 per whorl, curving backwards towards the convex side, and are covered by parallel riblets. No septal characters are seen. From the Lower Llandovery Shales. Both the specimens are in the Museum of the Geological Society.

General Description.—In all the collections examined there are but few examples of either of these forms, and they do not range themselves definitely in two groups as though there were two species, but are most satisfactorily considered as belonging to one rather variable one. An extremely instructive specimen (Pl. XXI. fig. 6) from the Bala Beds, Sholeshook, seems further to justify this union. Its rate of increase on one side is 1.45, and the last whorl is .37 of the whole, thus agreeing fairly well with the first variety, but it shows decided signs of asymmetry. There are $2\frac{1}{4}$ whorls, but all is septate. The ornaments are seen to change with growth. In the first $1\frac{1}{2}$ whorls they are merely fine riblets, only occasionally rising to a stronger one, but later on fairly strong ribs are developed, still covered by the riblets, and all curving back as in the type. We are thus permitted to consider that

var. α represents the young form and var. β the more adult, accounting for the difference of dimensions by the distortion and compression. In the example figured by Portlock (refigured Pl. XXVIII. fig. 5) we have the body-chamber preserved, and it is seen more or less to leave the coiled portion, but the aperture is not reached. The septa (fig. 6) are uniformly concave, but make a backward sinus on the front, and there are 32 per whorl, but no siphuncle is seen in this specimen, but one *seems* to show it a little within the centre.

Relations.—Salter unites to this species the *Lituites perfectus* of Wahlenberg, and the *L. lituus* of Hisinger, but the present is undoubtedly a *Trochoceras.* Its nearest ally is the Upper Silurian *T. striatum*, which has a much broader whorl at last, and its septa more remote.

Distribution.—In the Bala Beds at Presteign (1), Cerrig-y-druidion (2), Troutbeck (1), Sholeshook (1), Coniston (1), Desertcreat (1); and in the Lower Llandovery of Llandovery (2).

It has also been recorded by Lapworth from the Middle Silurian, Wrae; by Davies, from Bala; and by Sedgwick, from the Coniston Limestone.

Trochoceras asperum, Barrande, Pl. XXIX. fig. 3.

1865. Trochoceras asperum, Barrande, 'Syst. Sil. de Bohême,' vol. ii. pl. 16, 19, p. 104.

Type.—The Bohemian species has rather a variable rate of increase, about 1.63. The last whorl is .42 the diameter, with the earlier whorls in contact. The section is elliptic, the long diameter in the plane of curvature, in the ratio of 6 to 5 to the short one. The ornaments are sharp oblique ribs 17 or 18 per half whorl, making a deep curve on the front, where they are as strong as elsewhere, but they are very feeble on the concave side. There are longitudinal as well as transverse lines covering the ribs, but the former are very variable. The body-chamber is continued in a straight line, leaving the coiled portion; the ribs die off towards its extremity, and the aperture is simply transverse, bounded by lines of growth. The septa are as remote as the average ribs, about 36 per whorl; they have considerable convexity of surface, and are only slightly curved. The siphuncle is midway between the centre and the exterior. It is from the stage E, or Upper Silurian.

General Description.—The English specimens referred to this species have a rate of increase 1.53, and the last whorl is .42 of the diameter. The whorls slightly overlap, and the asymmetry is well marked. The section is an ellipse, not very convex on the sides but more so on the front. The axes are in the ratio of 6 : 5, and the long axis is in the plane of curvature. There are 16 very prominent subseparate ribs per half whorl, curving rapidly back, and more marked on the front than on the sides, and bearing parallel lines of growth. The body-chamber is partly out of contact, and the ribs die away and leave only lines of growth, which by their close-

ness indicate a direct and simple aperture. If a small specimen, associated in the same rock with some of those here referred to, be rightly considered to belong to the same species, from their rapid increase, from the general character of their ornaments, and especially from the greater strength of ribbing on the front, we learn that the section was more nearly circular in youth, and the curve of the ribs on the front is not so deep. The siphuncle in this is central, and it has not been seen in any other specimen of this species.

The chief difference between these and the Bohemian type is the rarity of any longitudinal lines, but these are variable, and may easily be lost in the preservation of the fossil. Nevertheless a somewhat similar fossil from the Upper Ludlow shows longitudinal lines, but this may be a distinct species, e.g. *Trochoceras Sandbergeri.* The septal characters also render the determination doubtful, yet the general proportions and ornaments, especially the nature of section, which is rare among *Trochocerata,* the prominence of the ribbing, and the changes in the body-chamber, which are the chief features in the Bohemian, are seen in the English examples.

Relations.—This species is distinguished from *T. giganteum* by the shape of its section and the persistence of the ribs on the front, and from *Trochoceras cornu-arietis* by the proportions of its whorls.

Distribution.—In the Wenlock Shale, Eastnor Park (3), and in the Wenlock Limestone at Ledbury (2). Also a young form associated with two latter, in the Woodwardian Museum, labelled *a* 952, and referred by Salter to *Trochoceras giganteum.* In the Lower Ludlow, Ledbury (2), and possibly in the Upper Ludlow of Presteign, which may be *T. Sandbergeri* (1).

TROCHOCERAS SPECIOSUM, Barrande, Pl. XXIX. figs. 1, 2, and Pl. XXVIII. fig. 3.

1865. TROCHOCERAS SPECIOSUM, Barrande, 'Syst. Sil. de Bohême,' vol. ii. pl. 14, figs. 12–15.

Type.—Barrande's figured specimen shows a rate of increase 1.39, and last whorl .31 of the diameter. The whorls are just in contact and the elevation is very slight. The section is elliptic, with the axes in the ratio of 11 to 9, the longer diameter being in the plane of curvature. The surface has only lines of growth. The body-chamber very slightly leaves the coiled portion. The septa are 28 in half a whorl. They bend rapidly forward to the front, and their surface is very slightly convex in a transverse direction. Siphuncle external and bulbous. Diameter 30 lines. The type appears to be unique; it occurs in stage E, or Upper Silurian, of Bohemia.

General Description.—Two of the specimens referred to this species show an almost exact correspondence with all its characters, but those that are flattened and distorted do not agree so well. The rate of increase is 1.43, and the last whorl .31

of the diameter. Another has the typical rate of increase, and the last whorl .35 of the diameter. The whorls scarcely touch, owing to the want of symmetry. The section is elliptic, the long diameter in the plane of curvature being $13\frac{2}{3}$ lines when the short is 11 lines. The surface was probably smooth. The septa are 32, or even more, in half a whorl (fig. 3); they are nearly straight at first and then bend rapidly forward to the front, and are almost flat transversely. The siphuncle is external and bulbous.

Relations.—The only other smooth, little elevated *Trochoceras* in British strata is *T. tortuosum*, whose section at once distinguishes it. Among the Bohemian forms *T. anguis* has a less proportionate thickness of whorl, and *T. priscum*, which seems to be the commoner species, has a compressed front.

Distribution.—In the Wenlock Shale, Ledbury (1); in the Wenlock Limestone, Ledbury (1) and Dudley (1); and in the Lower Ludlow of Ledbury (5) and of Mocktree (1).

TROCHOCERAS GYRANS, Blake, Pl. XXIX. fig. 4.

Type.—Rate of increase 1.5, last whorl .28 of the diameter. Thus the whorls are slightly out of contact throughout; $1\frac{1}{2}$ whorls are seen. The elevation is very slight; and the section is slightly quadrate. The ornaments are only backward-curving lines of growth, which are somewhat grouped on the inner side, and especially on the earlier part. No septal characters seen. Diameter 47 lines. From Wenlock Limestone, Eastnor. In the collection of Dr. Grindrod.

General Description.—Another example in the same collection, also in limestone, shows two whorls, of which the first is certainly unsymmetrical. The dimensions are the same, as are the subquadrate section, a little broader than thick, and the general smoothness. The body-chamber occupies $\frac{1}{2}$ a whorl at least. Septa not clearly seen, but their convexity is not slight. With these may be associated a fossil in the Museum of Practical Geology, whose rate of increase is 1.45 and breadth of last whorl is .24 of the whole, the difference being possibly due to the imbedding of the whorl in the stone. The septa are approximate $\frac{1}{5}$–$\frac{1}{6}$ diameter apart, the sutures undulating; the siphuncle is $\frac{2}{3}$ the diameter towards the outside and consists of oblique bulbs. There is thus no proved connection between these beyond their proportions being somewhat similar, making both evolute, so that the true septal characters of *T. gyrans* may be different.

Relations.—The nearest form to this is *T. speciosum*, whose whorls are only just in contact, if even they really are, and which has a smooth surface. The present, however, is *more* evolute, its section is more quadrate, and of course, if the example above described really belongs to it, the septal characters are quite distinct, as indeed the convexity of the septa in any case is.

Distribution.—In the Wenlock Limestone, Eastnor (2), Usk (1), and Ledbury (1).

TROCHOCERAS REGULARE, Blake, Pl. XXIX. fig. 7.

Type.—The rate of increase is 1.5, and the last whorl is .33 of the whole. The section is a rather flattened oblong, rounded at the edges. The whorls slightly overlap, and there is decided asymmetry. The ornaments consist of very clean and separate backward-curving ribs 22 per whorl, which stand out from the flat surface in the centre of the whorl, but die away partially over the front. The whole is so covered with the shell, that no septal characters are observable, and it is unknown how much belongs to the body-chamber. From the Wenlock Limestone, Dudley. In the British Museum.

General Description and Relations.—No other example of this very distinct form has been seen. In shape it is nearest to *Nautilus quadrans*, but its ornaments are different.

Distribution.—In the Wenlock Limestone, Dudley (1).

TROCHOCERAS TORTUOSUM, Sowerby, Pl. XXXI. figs. 3, *3a*.

1839. LITUITES TORTUOSUS, Sowerby in Murchison's 'Sil. Syst.' pl. 11, figs. 3, p. 622.
Syn. 1865. TROCHOCERAS OXYNOTUM, Barrande, 'Syst. Sil. de Bohême,' vol. ii. pl. 14, fig. 1–11, p. 91.

Type.—Rate of increase 1.29; last whorl .3 of the whole. The outer whorls slightly overlap the inner, and scarcely any elevation is observable. The section is rounded-lanceolate, rising to the greatest thickness at $\frac{1}{3}$ the whorl-breadth from the umbilical edge, whence there is a gentle slope to the front, which is subangular. Ratio of thickness to breadth as 13 to 18. No ornaments. The shell is of considerable thickness. The septa bend slightly backwards on the inner side of the whorl, and then rapidly forwards, meeting at an angle on the front. They are very numerous, 50 per whorl; the septal surface has a convexity of $\frac{2}{9}$ the long diameter of the whorl, the inner part being flatter. The siphuncle is external, in the angle at the front, and has a diameter on the septal surface of $\frac{1}{9}$ the whorl-diameter. Diameter about 30 lines.

The specimen on which Sowerby's species was founded, which is in the collection of the Geological Society, consists of two pieces, of which the larger only was figured, or perhaps even seen. When put together, they form an ordinary involute *Trochoceras*. The matrix is a black calcareous nodule, said to be from the Lower Ludlow, between Welchpool and Berriw.

General Description.—I have only seen one other example which could be referred to this species. It is in the Gray Collection in the British Museum. It has the same shape of section; the thickness being $\frac{11}{18}$ of the whorl-breadth. The increase is very slight in the body-chamber, here seen, and the curvature con-

sequently is less, and the section becomes more rounded on the front. There is no certain contraction at the aperture. The septa are equally close; the siphuncle is in the same position, and has a slightly bulbous form.

Relations.—This seems to agree in every respect with Barrande's *Trochoceras oxynotum*, and the section and other characters are so remarkable, even as shown by Sowerby, that it is rather astonishing that Barrande should have made no reference to it, but have passed it by as a *Cyrtoceras.*

Distribution.—In the grey mudstone, ? Lower Ludlow, of Dudley (1), and in limestone referred to in the Lower Ludlow near Welchpool (1).

TROCHOCERAS STRIATUM, Blake, Pl. XXIX. fig. 5; and Pl. XXX. figs. 3, 4, 4*a*, 4*b*.

Type.—The rate of increase is 1.74, and the last whorl is .4 of the diameter. The want of symmetry is very slight. The section is uniformly rounded, but rather flattened. The body-chamber continues the same curve as the earlier portion. The ornaments are 33 almost obsolete, rounded, subseparate ribs, curving very rapidly backwards, and these die away on the body-chamber, leaving only lines of growth. The septa are 24 per whorl, and the sutures are somewhat sigmoid, commencing by being slightly convex towards the aperture, on the inner edge. There are some bulbous-looking bodies on the circumference, which may represent an external beaded siphuncle. Diameter 3 inches. From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.

General Description.—Other examples confirm the great rapidity of growth, and the breadth of the outer whorl. The thickness is about $\frac{1}{2}$ the breadth, and in some there are very good indications of asymmetry. The body-chamber is not longer than its basal diameter, and the aperture is formed of a gentle sigmoid backward tending curve parallel to the lines of growth, about $\frac{1}{9}$ the diameter apart (Pl. XXX. fig. 3). The shell, when well preserved, is covered by fine lines parallel to the ribs, which are most conspicuous towards the convex border (fig. 4*a*), while epidermids cover the region near the concave border (fig. 4*b*). The septa are pretty uniformly concave; except near the inner border, their transverse convexity is slight; and their number pretty constant at 24 per whorl. The siphuncle is not certainly determined.

Relations.—Flattened examples of *Nautilus quadrans* may be taken for this species until one is familiar with its aspect, when it is unmistakable from its delicate ornaments and graceful contours. *Cyrtoceras compressum* is also somewhat similar, but the septa in that species are much closer, and of course the curvature is not so great.

Distribution.—In the Wenlock Shale, Usk (5); in the Lower Ludlow, Ledbury (2).

TROCHOCERAS GIGANTEUM, Sowerby, Pl. XXXI. figs. 1, 2.

1839. LITUITES GIGANTEUS, Sowerby in Murchison's 'Silurian System,' pl. 11, fig. 4, p. 622.
1855. HORTOLUS GIGANTEUS, M'Coy, 'Brit. Pal. Foss.' p. 324.
1865. TROCHOCERAS GIGANTEUM, Lyell, 'Elements of Geology,' p. 552.
1873. „ „ Salter, 'Camb. and Sil. Foss.' pp. 160, 174.

Type.—Rate of increase of coiled portion 1.5; last whorl .35 of the diameter. The whorls are just in contact till near the straight portion; there is very little elevation to be made out. The section is subquadrate, with the umbilical edge rounded, a little broader than thick (16 : 15), the straight portion becoming broader in proportion. The ornaments are transverse ribs, subacute, not very separate, nearly $\frac{1}{3}$ the breadth of the whorl apart at first, but becoming closer in proportion up to $\frac{1}{6}$; curving backwards toward the front, at first only slightly, viz. one rib interval, but gradually more so, till at last they reach back six intervals; they are more or less feeble on the front, but are not quite obsolete. The body-chamber begins at $\frac{1}{3}$ whorl before the straight portion. No change is seen towards the aperture, which is not reached. The siphuncle is nearly central, but slightly exterior. Its diameter on the septal surface is $\frac{1}{10}$ the whorl-breadth. The septa are direct, cutting the ribs; they are nearly $\frac{1}{2}$ the whorl-breadth apart in early whorls; their convexity is $\frac{1}{4}$ breadth. Diameter of coiled portion $4\frac{1}{4}$ in., length of straight portion $3\frac{3}{4}$ in. From the Lower Ludlow; locality not stated. In the Museum of the Geological Society.

General Description.—The rate of increase varies between 1.48 and 1.57; the breadth of the last whorl being from .31 to .35 of the whole, always bringing the whorls just into contact, while the curvature remains constant. In several examples otherwise agreeing with the type, decided asymmetry is observed; in one of the figured specimens (fig. 2) this is associated with the peculiar form of aperture to be noticed below. The subquadrate section is characteristic, though the earlier whorls are more rounded. The breadth is always greater than the thickness—the proportion increasing with growth. In the other figured specimen (fig. 1), it reaches a maximum of 22 : 16. The front is usually rounded, but tends to become concave. The inside also when out of contact often retains some concavity. The ribs are rather of irregular character, being sometimes rounded, sometimes more acute, but always rough. On the average they are about $\frac{1}{5}$ the whorl-breadth apart, or 26 per whorl, growing closer with age. They are direct on the inside when exposed, and curve back on the sides to meet at a rounded angle on the front, where they either become feebler with intermediate ribs, or break up into smaller ones; the whole are generally continued to the aperture, but the ribs are sometimes replaced by lines of growth. The surface is seldom well enough preserved to show

the parallel lines of growth on the ribs, but often the epidermids of the under-layers are visible. These are direct, crossing the ribs, from 14 to 22 per line. There are also longitudinal ones on the inner side when exposed. The body-chamber always includes part of the normally-coiled portion, and extends a variable distance in a nearly straight line. The largest seen was 8 inches long, but it is impossible to say what proportion this bore to the coiled portion. This and several smaller ones show no difference on approaching the aperture, which seems to be indicated by the deeply back-curving ribs; but in one or two instances there is a decided contraction just at the aperture on each side of the whorl, as in fig. 2, dividing it, as seen in full view, into two wider portions, separated by a narrower, and yet not forming a contracted aperture in the same sense as in the *Phragmocerata*. The septa are direct across the front; but on the sides, their general direction being radial, they become concave at some part, so that they cut across the ribs, and do not coincide with the epidermids, and they thus on the whole become sigmoid in form. They do not bear a fixed proportion to the ribs, but are sometimes more, sometimes fewer, the last few being closer, up to $\frac{2}{11}$ the whorl-breadth. The convexity of the septal surface is pretty constant at about $\frac{1}{4}$ the whorl-breadth. The siphuncle is nearly invariable, a little beyond the centre.

Relations.—The chief difficulty about this species is the decision of its genus. It has undoubtedly a considerable portion uncoiled, and might therefore be a *Lituites*. On the other hand, it is unsymmetrical, as seen in fig. 2, which has a complex aperture, and hence should be a *Trochoceras*. I prefer the latter interpretation, as the straight portion forms a comparatively small part of the shell compared with that of the true *Lituites*, and it has not been satisfactorily proved that the whorls of the latter genus are ever in contact.

Distribution.—In the Wenlock Shale of Dudley (3); in the Wenlock Limestone at Wenlock (1) and Dudley (3); abundant in the Lower Ludlow of Leintwardine (10), also of Ledbury (18), in the collection of Dr. Grindrod; in the same horizon at Usk (1) and Llanbadock (1), and in the neighbourhood of Cardiff (1).

M'Coy in his 'Palæozoic Fossils' records this species from Upper Bala, Builth; but I have seen no true representative of it in those beds. It is also recorded by Professor Phillips, from Upper Silurian at Llandeilo and Abberley; by Professor Hughes, from the Coniston Flags; and by Salter, from the Coniston Grit, and from the Lower Ludlow, at Parkes Hall, Staffordshire, and at Coalbrookdale.

TROCHOCERAS RAPAX, Barrande, Pl. XXX. figs. 2, 2*a*.

1865. TROCHOCERAS RAPAX, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 21, 22, p. 124.
1877. „ „ Barrande, loc. cit., Supplement, pl. 493, p. 89.
Syn. 1865. TROCHOCERAS PINGUE, Barrande, loc. cit., pl. 17, fig. 5, p. 112.

Type.—Fragments only of this species are described by its author. They are of large size, and consist of the later septal- and body-chambers; the rate of increase cannot therefore be defined, and the transverse growth as seen in the sections is not uniform, being more rapid in the earlier portion. In the body-chamber it is 1 in 14, measured along the outer curve. There is very little sign of asymmetry. From the manner in which the ornaments pass over the inside, it must have been evolute throughout the portions preserved. The section is very roundedly quadrate, the chief flattening being on the front. In the earlier part the diameters are very nearly equal, but it becomes more transverse with age. The ornaments are strong ribs, which curve backwards and make a deep sinus on the front, where they break up into finer ones; they pass horizontally across the concave side without becoming more feeble. They are about $\frac{1}{6}$ the mean diameter apart in the middle of the side. There are minor ornaments formed by fine longitudinal and transverse raised lines and epidermids on the cast. The ribs become feebler towards the aperture, which is oblique in the same direction, but at a greater angle than the ribs, and thus there is a deep sinus on the front, but no contraction. The septa are moderately convex, but the sutures are not very concave, but have so much of a forward curvature towards the outside as to cut across four of the ribs; they are four in number to every three ribs; the siphuncle is a little beyond the centre towards the outside. The largest is about 10 inches long. From the band E 2, or lower part of the 3rd Fauna, or Upper Silurian.

General Description.—Two very admirably preserved examples, one in the British Museum and the other in the collection of Dr. Grindrod, give certain proof of the presence of a *Trochoceras*, in which the earlier whorl leaves a very wide interval between itself and the body-whorl, and which therefore is evolute for some distance at least previous to the last chamber. Measurements of the rates of increase show that it becomes much greater with the growth, varying indeed from 1.22 to 1.9, and the last whorl varies from .23 to .31 of the whole. From this we may expect that the earlier whorls are in contact. The section as seen in Dr. Grindrod's specimen is roundedly quadrate, rather flattened on the outside (fig. 2), and the two dimensions are equal. In a younger example it is a little thicker than broad, with the greatest thickness near the inside. The ornaments are well-marked, separate ribs, slightly convex forwards, but curving rapidly back on the whole so as to make a sinus on the front; they are equally conspicuous all round, but feeble on the cast. There are 36 of

these per whorl, or they are about $\frac{1}{5}$ the diameter apart. There are radial epidermids on the surface about 12 to 22 per line, which pass over the ribs and continue across the inside. The body-chamber is scarcely seen to become straight, and the ribs scarcely die away. The septa have considerable convexity, about $\frac{1}{4}$ their diameter. The sutures are nearly radial, or even slope backwards, but much less so than the ribs, four of which they cut. They are rather fewer than the ribs at first, but become equal in number in the same space at last. The siphuncle is a little beyond the centre towards the outside, about $\frac{2}{3}$ out in an example smaller than the rest. The diameter is about 5 inches, and the length of the body-chamber is about the same.

Relations.—The general structure of this shell, the shape of the section, the position of the siphuncle, the character of the ribbing, are very much the same as in *Trochoceras giganteum*, to which the specimens have been hitherto referred. But in the type of the latter, as seen from the previous description, the whorls are in contact. Herein lies the difference, but at the same time the ribs in the present species are closer, more separate, and more continuous all round; the aperture has a different character, and the septa are closer. They must, however, be placed in the same genus, and hence, though the whorls are out of contact, that of *Trochoceras* is adopted for the present one. The characters given by Barrande to his *T. pingue* disagree in no respect with the figures of *T. rapax*, on to the smaller end of which the former might very well fit. It is therefore a synonym.

Distribution.—In the Lower Ludlow, Ledbury (3); and in Wenlock Shale (?), Dudley (2).

Trochoceras undosum, Sowerby, Pl. XXX. figs. 5, 5*a*, 6.

1839. Nautilus undosus, Sowerby in Murchison's 'Sil. Syst.' pl. 22, fig. 17, p. 642.
1848. Lituites undosus, Salter, 'Memoirs of Geol. Survey,' vol. ii. pl. 1, p. 352.

Type.—Contorted. Rate of increase about 1.4, last whorl about .3 of the whole; whorls very slightly indented by the previous ones. The section is rounded quadrate, flat on the front. Thickness $\frac{9}{10}$ of the whorl-breadth. The ornaments are backward-curving undulations only perceptible towards the outside, where the elevations rise into knots, about 11 per half whorl, which are nearly lost again on the front. The body-chamber occupies $\frac{1}{3}$ whorl, and continues slightly beyond the coiled part, the section widening out a little on the inside. The septa are concave on the sides and front, coming to forward pointing angle at the edge of the latter (fig. 5*a*). There are 22 in the last half-whorl. The siphuncle is not seen. Diameter $3\frac{1}{4}$ inches. From the Lower Llandovery Grits, at Blaen-y-cwm. In the Museum of the Geological Society.

General Description.—I have only seen two other specimens possibly referable to this. In one the section is more elliptic, but the general proportions are the same. The knobs in this smaller specimen are more remote, namely, at every third chamber. The septa are $\frac{1}{5}$ whorl-breadth apart. The other specimen which is figured (fig. 6) is evidently young; but from its shape it seems to indicate that the defect from regular curvature in the larger ones may be natural. In none of these is the position of the siphuncle seen. Salter states it to be internal. There is a specimen bearing this name under his hand in the Museum of Practical Geology, with an internal siphuncle; but this I take to belong to his subsequently established species, *Trocholites planorbiformis.*

Relations.—No British form approaches this in the slightest. It is placed as a *Lituites* from its general appearance; but it may be a *Nautilus*, like the *Discites* of the Carboniferous rocks, in which group indeed it might well be placed.

Distribution.—In the Lower Llandovery Grits at Blaen-y-cwm (1), Mandinam (1), Llandovery (1).

Genus LITUITES.

LITUITES? ARIETINUS, Barrande, Pl. XXXI. figs. 4, 4*a*.

1865. TROCHOCERAS ARIETINUM, Barrande, 'Syst. Silur. de Bohême,' vol. ii. pl. 17, 25, 103, p. 103.

Type.—The specimens figured by Barrande show an inconstant curvature, the outline being elongated in one direction, also a varying rate of increase. But the last whorl is about $\frac{1}{4}$ the diameter, and the inner whorl is scarcely, if at all, in contact. The elevation is very slight. The section is oval and flat on the front, and the thickness is greater than the breadth, but the proportion is very different in the three specimens. The body-chamber is more than half a whorl. The ornaments are transverse ribs, about 40 per whorl, sharp, separate, curving obliquely backwards. They are obsolete on the front, and replaced there by lines of growth. On the concave side they are direct. The whole is covered by parallel lines of growth, and on the concave side are obscure traces of longitudinal lines. The septa are direct, concave on the side, and rise towards the aperture over the front. The siphuncle is a little exterior to the centre. Transverse epidermids are seen on the cast. The type is from the zone E of Barrande, or Upper Silurian.

General Description.—The English specimens referred to this species have a rate of increase in different parts from 1.35 to 1.81, and a breadth of last whorl from .2

to .24 of the diameter. The whorls are elongated in one direction, so that the general contour is more elliptical than circular, and they are out of contact. No asymmetry is observable. The section is rounded on the sides and flat on the front; but the breadth is greater than the thickness, which may very well be due to compression. The ribs, from 26–40 per whorl, are backward curving, acute, separate, dying away into several deepish riblets on the front (fig. 4*a*), which meet in a rounded curve. The body-chamber is more than half a whorl, and is continued for some distance in a straight line. The septa are uniformly concave to the aperture, direct on the whole, about $\frac{1}{2}$ or less part of the whorl-breadth apart. One specimen shows transverse epidermids. The only differences between our English specimens and the Bohemian are that the section is not transverse in the former; but none of the specimens are uncompressed; also that no longitudinal lines have been observed, and the septa are a little wider apart. The remarkable proportions, the flatness of the front, and the character of the ribs, including their dying off on the front, are well exemplified.

Relations.—The proportions of the whorls distinguish this from *Trochoceras rapax*, to which it is allied by its ornaments and its whorls being out of contact. It is doubtfully placed as a *Lituites* from its loose appearance.

Distribution.—In the Lower Ludlow rocks of Ledbury (4).

Lituites ibex, Sowerby, Pl. XVIII. figs. 3, 4, 4*a*, 5.

1838. Lituites ibex, Sowerby in Murchison's 'Silurian System,' pl. 11, fig. 6, p. 622.
1852. Hortolus ibex, M'Coy, 'Pal. Foss.' p. 324.
1848. Orthoceras perelegans (part), Salter, 'Mem. Geol. Survey,' pt. 2, pl. 13, fig. 4 (not figs. 2, 3).
1854. „ „ Salter in 'Siluria,' pl. 29, figs. 5, 6.
1873. „ „ Salter, 'Camb. and Silurian Fossils,' p. 187.
1873. Orthoceras tracheale, Salter, loc. cit., pp. 187, 192.

Not 1838. Orthoceras ibex, Sowerby, loc. cit., pl. 5, fig. 30.

Type.—Sowerby's type of *Lituites ibex* must not be confounded with his *Orthoceras* of the same name, which he thought might belong to the same species, but which is really different. I have not been able to discover the type, though Salter appears to have done so, and to have identified it with his *O. perelegans.* The figure shows no section, and it may be circular. The curvature has at first a radius of $\frac{5}{8}$ of an inch only for the convex curve, but it soon diminishes to nearly zero. The rate of increase measured as on a curved shell is 1 in 11. No characters of body-chamber, aperture, septa, or siphuncle, are observable. The ornaments consist of sharp transverse riblets, from $\frac{1}{3}$ to $\frac{2}{7}$ the diameter apart, slightly oblique, curving backwards to the convex side in the more coiled portion; they are non-separate, the

interspaces being uniform concavities between the crests. Salter would appear to have seen transverse striæ on it. Length, $2\frac{3}{4}$ inches; greatest diameter, $\frac{1}{3}$ inch. From Ludlow Beds, Black Mountain, Clun Forest.

General Description.—The section, as Salter states in the description of his *O. perelegans*, is probably circular. The flattening always takes place in the plane of curvature. The radius of curvature is in none so small as in the type. In the smallest, almost reaching the apex, it is $\frac{5}{6}$ inch, and the curvature gradually decreases as the fragments are of larger diameter—and those which show the aperture are nearly straight there; some also may have longer straight portions. The earlier portion forms an open coil, the whorls not being in contact. The greatest rate of increase observed is 1 in 9, and this decreases with the curvature to almost zero. The aperture is not contracted, but formed by a sigmoid curve which bends rapidly forward on the convex side as to a beak; it is concave forwards on the side, and curves back to form a sinus on the inner side. The ornaments consist of, first, sharp non-separate ribs, at first $\frac{1}{2}$ the diameter apart, becoming closer to an average of $\frac{1}{3}$ the diameter, though appearing still closer by compression, and finally dying off on the body-chamber on approaching the aperture—these rather undulate, or are oblique, sloping backwards to the exterior; secondly, there are fine riblets parallel to these, numbering from 10 to 20 in the interval between two ribs, and degenerating into lines of growth on the unribbed part. The septa lie parallel to the ribs in the intervals between them, and are thus about $\frac{1}{3}$ the diameter apart; their convexity is between $\frac{1}{5}$ and $\frac{1}{6}$ the diameter. The siphuncle is small and central. The type is the longest species. The greatest diameter of the more curved part is $\frac{5}{8}$ inch.

Relations.—Although, as we have seen, some *Orthocerata* and a *Cyrtoceras* have very similar, though not identical ornaments, yet the changes of the curvature which take place in this are of sufficient importance to separate it from them all; and if the large species doubtfully referred to the present genus or to *Trochoceras* should be assigned to the latter, this would be the only true *Lituites* in the British fauna. However straight the last part may be, there is seldom wanting some indication of its true character.

Distribution.—In the Lower Ludlow of Ledbury (6) and of Leintwardine (3); in the Upper Ludlow of Ludlow (4), Malvern (3), Kirby Moor (1), and Underbarrow (1); and in the Tilestone of Horeb Chapel (1) and Llandeilo (1).

Genus Ophidioceras.

Ophidioceras articulatum, Sowerby, Pl. XVIII. figs. 14, 14*a*, 15.

1838. Lituites articulatus, Sowerby in Murchison's 'Sil. Syst.' pl. 11, fig. 5 (not fig. 7), p. 622.
1873. ,, ,, Salter, 'Cambrian and Silurian Foss.' p. 174.

Not Lituites articulatus, M'Coy, 'Palæozoic Fossils,' p. 323.

Type.—Mean rate of increase 1.31. Last whorl .27 of the whole, the several whorls being just in contact. There are indications of the last whorl leaving the rest by the diminution of curvature. The shape of the section is unknown, but the outside looks as if it were keeled. The nearly straight ribs are narrow and separate, and have a sigmoidal bend outside. No septa or siphuncle seen. Diameter $1\frac{1}{4}$ inches. From the Lower Ludlow of Elton, near Ludlow. In the Museum of the Geological Society.

General Description.—The rate of increase, as measured, ranges from 1.43 to 1.29; but from the compression to which the specimens have been subjected, these measures are seldom very reliable. The inner whorls are always just in contact—till the body-chamber, which leaves the coiled part at a diameter from 9 to 14 lines, and continues straight for $\frac{2}{3}$ the greatest diameter. In an obscure fossil referred to this species from the Wenlock Shale, the uncoiled part reaches twice this distance. There is no sign in any of the slightest want of symmetry. The ribs are always direct, more or less separate, with a slightly backward direction towards the outside, from 26 to 28 per whorl. The front had a flattened band along it as shown by two smooth parallel lines in more than one example. The finer ornaments are parallel lines of growth, and the surface is occasionally pitted (fig. 4*a*). The section when unflattened is uniformly rounded. The body-chamber consists of some part of the coiled portion; the ribs die out towards the aperture, which is not seen to be contracted. The septa are more remote than the ribs, being but 14 per whorl in the earlier part. The siphuncle is only seen in one example in the Wenlock Limestone, where it is nearly external, being preserved after the decay of the shell. The diameter is never more than $1\frac{1}{2}$ inches.

Relations.—The straight ribbing and the band along the front easily distinguish this from previously described British forms; but it is very similar to some of the other *Ophidiocerata* figured by Barrande on pl. 45 of his Silurian Cephalopods, with none of which, however, it exactly agrees, but is nearest to *O. tenerum*, or *O. simplex*. The contracted aperture has not, however, been seen in British examples.

Distribution.—There are but few good examples of this rather rare species. It occurs in the Wenlock Shale at Oernant (1), in the Wenlock Limestone of Wen-

lock (1) and Dudley (1), and in the Lower Ludlow at Elton (1), Dudley (1), Ludlow (3), Ledbury (1), Newton (1), Craig Vale (1), and Malvern (1).

It is recorded also by Salter from Upper Llandovery (?) at Nant Glyn, and from Lower Ludlow, at Parkes Hall, and by J. F. Brown, from the Upper Silurian of the South Wales area. These references, however, may be to *O. ibex* or *Cyrtoceras extricatum.*

Ophidioceras geometricum, Blake, Pl. XVIII. figs. 16, 16*a*.

Type.—The rate of increase is 1.5 and the last whorl .31 of the whole, the whorls being just in contact. The last chamber leaves the earlier whorls for some space. The character of the section is not seen. The aperture is bounded by sigmoid lines, and has an inflation on the inner side, giving it a proboscis-like form. The ornaments are subacute, separate ribs, which run radially, and appear to be lost on the front, which has the same appearance of a keel as in *Oph. articulatum.* There are 32 per whorl, but they die away on the straight portion, which has only lines of growth. The whorl is crossed by a number of sharp spider-lines, which pass across the ribs so as to transgress nearly a rib-interval in their passage outwards; these are 8 per space. Diameter 1 inch. From the Lower Ludlow of Ludlow. In the British Museum.

General Description.—Two other specimens from different localities show the peculiarities of this form; the rate of increase being 1.53, and the last whorl .33 of the diameter. The aperture is seen only in the type. The ribs may be as few as 27 per whorl, and bend back towards the outside, but there is the same appearance of a keel, probably due to a flat band, in all, and the remarkable thread-like lines transgressing the ribs, 7 per space. No septal characters are anywhere seen.

Relations.—It may seem at first sight improper to separate this from *Oph. articulatum*, which it so closely resembles. But the reason for this resemblance is that they both belong to a small group of shells, characterised by nearly straight ribs, and by a band along the front, but which show many minor differences by which they may be distinguished. (See Barrande, 'Syst. Silur de Bohême,' pl. 45.) The present species has a broader last whorl and greater rate of increase than any of those referred to *Oph. articulatum.* The ribs are perhaps not quite so straight; and, above all, though specimens of the last named, with ornaments perfectly preserved, have been seen, they do not show the remarkable transgressive threads of the present.

Distribution.—In the Lower Ludlow rocks of Ludlow (1), of Ledbury (1), and of Dudley (1).

Suborder AMMONITOIDEA.

Genus Goniatites.

Goniatites (?) nautilaceum, Sowerby, Pl. XXVII. fig. 4.

1838. Phragmoceras (?) nautilaceum, Sowerby in Murchison's 'Sil. Syst.,' pl. 10, fig. 2 (not fig. 3), p. 622.

Type.—This only shows the surface flattened on a piece of mudstone. Its shape is so peculiar that Sowerby placed a query after the genus, but he associated with it a really different form without that peculiarity. It has, as he states, very much the aspect of a *Nautilus*, that is of a *Nautilus* of Neozoic age, inasmuch as it is nearly involute, the last whorl occupying $\frac{7}{11}$ of the whole diameter, and the umbilicus being nearly zero. The ornaments are slightly irregular, transverse diverging ribs, imbricating slightly backwards, and very feeble striæ parallel to them. These are convex towards the aperture, curving first forward and then back towards the outside, about 24 in half a whorl. The aperture shows no signs of contraction, but the curvature remains normal. No septal characters are visible. The absence of any characters of septa, siphuncle, and aperture must necessarily leave the genus doubtful till better specimens are met with. In the meantime there is no contraction of the body-chamber, and the shape is not that of a *Phragmoceras*. The shape, indeed, being all we have to go by, points to *Goniatites* as the most probable genus, examples of which from Silurian rocks have a similar shape, and we can say this of no other genus. Diameter, $2\frac{1}{4}$ inches. In the Museum of the Geological Society. From the Lower Ludlow.

General Description.—The type is unique.

Distribution.—In the Lower Ludlow at Charlton Brook, south end of the Longmynd.

Phillips records some species by this name from Freshwater, Haverfordwest, and Llandeilo, and Salter from the Upper Llandovery, Plas Madoc, but there is every probability they mean some other form.

TABLE OF THE DISTRIBUTION OF CEPHALOPODA IN THE BRITISH SILURIAN ROCKS.

× *Indicates that specimens have been examined;* ⊙ *that the species has been recorded.*

Name.	Tremadoc.	Llandeilo.	Bala.	Lower Llandovery.	Upper Llandovery.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow.	Upper Ludlow.	Tilestones.	Europe.	America.
ORTHOCERAS												
Barrandei . .	..	..	..	..	⊙	×	×	×				
xit	..	..	..	..	..	×						
mendax . . .	..	×										
baculoide . .	..	×										
durinum . . .	..	×										
arcuoliratum .	..	?	⊙	..	..	..	..	..	..	..	..	⊙
perannulatum .	..	×	×									
gracile . . .	..	..	×									
velatum . . .	..	..	×	×								
Nicholianum. .	..	..	..	..	×	..	×	×				
annulatum . .	..	..	×	..	×	×	×	×	×	..	⊙	⊙
Duponti . . .	..	..	..	..	..	×	..	×				
subannulare . .	..	..	..	..	..	×	..	×				
ibex	..	..	..	..	..	×	..	×	×	..	⊙	
tracheale. . .	..	..	..	..	..	⊙	..	×	×	×		
tenuiannulatum .	..	..	..	..	×	..	..	×	×			
kendalense . .	..	..	..	..	..	..	..	×	×			
adornatum . .	..	..	..	..	..	..	..	..	..	×	⊙	
Grayi . . .	..	..	..	..	..	..	×	×				
dimidiatum . .	..	..	..	..	..	×	..	×	×			
Etheridgii . .	..	..	..	..	..	×						
Maclareni . .	..	..	..	..	..	..	..	×	×			
angulatum . .	..	..	×?	..	⊙	×	×	×	×	..	⊙	⊙
coralliforme . .	..	..	×									
originale . . .	..	..	..	..	..	×	..	×	..	..	⊙	
Bacchus . . .	..	..	..	..	×	×	×	×	×	..	⊙	
filosum . . .	..	..	⊙?	..	..	×	..	×	×			
fimbriatum . .	..	..	..	..	..	..	×	×	×	..	⊙?	
argus	..	..	×	..	..	×	..	×	..	..	⊙	
expansum . .	..	..	×									
elongatocinctum.	..	..	×	..	⊙							
undulocinctum .	..	..	..	..	..	..	..	..	×			
recticinctum .	..	..	×?	×	..	×	×	×	×			
pendens . . .	..	..	×									
Grindrodi . .	..	..	..	..	..	..	..	×	×			
pomeroense . .	..	..	×									
araneosum . .	..	..	..	..	..	×	..	..	×	..	⊙	
semipartitum .	..	..	⊙?	..	..	..	..	..	×	×		
Carried forward	0	4	10	2	4	15	8	20	16	3	8	3

TABLE OF THE DISTRIBUTION OF CEPHALOPODA IN THE BRITISH SILURIAN ROCKS—*continued.*

NAME.	Tremadoc.	Llandeilo.	Bala.	Lower Llandovery.	Upper Llandovery.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow.	Upper Ludlow.	Tilestones.	Europe.	America.
Brought forward	0	4	10	2	4	15	8	20	16	3	8	3
ORTHOCERAS												
lineatum . . .	..	..	×	..	..	..	..	..	..	..	⊙	
var. tenuistriata	..	..	×	×	×	×						
bullatum. . .	..	..	..	..	..	×	×	×	×	×		
Avelinii . . .	..	×										
ascendens . .	..	..	×	..	..	..	..	×?				
subundulatum .	..	⊙?	×	..	⊙	×	..	×	×			
fretum . . .	..	..	..	..	..	×	..	..	×			
Saturni . . .	..	..	×?	×	..	..	..	×	×	..	⊙	
mocktreense . .	..	..	..	..	..	..	⊙	×	×			
reversum. . .	..	..	..	..	..	×?	..	×	×?			
sericeum . . .	×	×										
pertinens . .	..	×										
vagans . . .	..	×	×	..	..	..	..	..	..	..	⊙	
politum . . .	..	..	×	..	..	..	..	..	..	..	⊙	
audax . . .	..	..	×									
pictum . . .	..	..	×									
druidii . . .	..	..	×	..	..	..	..	..	×?			
ardvellense . .	..	..	×									
subgregarium .	..	×?	×	..	×							
gregarium . .	..	..	×	×	×	×	..	×	..	..	⊙	
primævum . .	..	..	..	..	⊙	×	..	×	×			
var. antiquior .	..	..	×									
subconicum . .	..	..	..	×?	×	×	..	..	×			
circulare . . .	..	..	..	..	×	⊙						
truncatum . .	..	..	..	..	..	×	×	..	..	..	⊙	
excentricum . .	..	..	..	..	..	×	..	⊙	×			
imbricatum . .	..	..	..	..	..	×	×	×	×	×	⊙	
perversum . .	..	..	..	..	..	..	×	×	×			
ludense . . .	..	..	..	..	×	×	×	×	×	..	⊙	
distans . . .	..	..	..	..	..	×	×	×	×	..	⊙	
baculiforme . .	..	..	..	..	..	..	..	..	×			
omissum . . .	..	..	..	..	..	..	..	..	×			
(*Endoceras*)												
cochleatum . .	..	..	×	×	×	×	×	..	×	×	⊙	
(*Actinoceras*)												
Brongniartii. .	..	..	×	..	..	..	..	..	..	..	..	⊙
festinans . . .	..	..	×									
vaginatum . .	..	..	..	..	⊙							
(*Tretoceras*)												
bisiphonatum .	..	..	..	×	..	×						
(*Conoceras*)												
eoum	..	×										
CYRTOCERAS												
præcox . . .	×											
llandoveri . .	..	..	..	..	×							
approximatum .	..	..	..	..	×	×?						
Carried forward	2	9	25	7	13	29	15	31	31	6	18	4

TABLE OF THE DISTRIBUTION OF CEPHALOPODA IN THE BRITISH SILURIAN ROCKS—*continued.*

NAME.	Tremadoc.	Llandeilo.	Bala.	Lower Llandovery.	Upper Llandovery.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow.	Upper Ludlow.	Tilestones.	Europe.	America.
Brought forward	2	9	25	7	13	29	15	31	31	6	18	4
CYRTOCERAS												
corniculum . .	..	..	..	..	..	×	×	..	..	..	⊙	
isca	..	..	..	..	..	×						
contrarium . .	..	..	..	..	..	×	×	..	..	..	⊙	
plebeium . .	..	..	..	..	..	..	×	..	..	..	⊙	
compressum . .	..	..	..	×	..	..	..	×	×			
magnum . . .	..	..	..	..	..	×	..	×	×			
fortiusculum. .	..	..	..	..	..	..	..	×	..	..	⊙	
intermedium. .	..	..	..	..	..	×?	..	×				
uranus . . .	..	..	..	..	..	..	..	×	..	..	⊙	
equisetum . .	..	..	..	..	..	..	..	×				
sonax. . . .	..	..	×									
macrum . . .	..	..	×									
reversum. . .	..	..	..	..	..	..	..	×				
inæquiseptum .	..	..	×									
subarcuatum. .	..	..	×	..	⊙							
extricatum . .	..	..	..	..	..	..	..	×				
multicameratum	..	..	⊙	..	..	..	..	..	..	..	..	⊙
scoticum . . .	..	..	×									
alternatum . .	..	..	×									
(*Piloceras*)												
(invaginatum) .	..	[×]										
POTERIOCERAS												
approximatum .	..	..	×									
intortum . . .	..	..	×									
GOMPHOCERAS												
æquale . . .	..	..	..	×?	..	×	×					
corona . . .	..	..	..	..	..	..	×					
crater . . .	..	..	..	..	..	×	×					
ellipticum . .	..	..	..	..	..	..	..	×	..	..	⊙?	
pyriforme . .	..	..	..	..	..	⊙?	⊙?	×	⊙?			
obovatum . .	..	..	..	..	..	..	..	×				
eta	..	..	..	..	..	..	..	×				
gratum . . .	..	..	..	..	..	..	..	×	..	..	⊙	
cinctum . . .	..	..	..	..	..	..	×	×				
neglectum . .	..	..	..	..	..	..	..	×				
amygdala . .	..	..	..	..	..	..	×?	×	..	..	⊙	
PHRAGMOCERAS												
prius	..	..	×									
ventricosum . .	..	..	⊙?	..	×	×	×	×	×			
imbricatum . .	..	..	..	..	..	..	×	×?	..	..	⊙	
obliquum . .	..	..	..	..	..	..	×	×?				
subexternum .	..	..	..	..	..	..	×					
arcuatum . .	..	..	..	..	..	..	×	×				
externum . .	..	..	..	..	..	..	..	×				
Carried forward	2	9	34	8	14	36	27	50	34	6	26	5

Table of the Distribution of Cephalopoda in the British Silurian Rocks—*continued.*

Name.	Tremadoc.	Llandeilo.	Bala.	Lower Llandovery.	Upper Llandovery.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow.	Upper Ludlow.	Tilestones.	Europe.	America.
Brought forward	2	9	34	8	14	36	27	50	34	6	26	5
Ascoceras												
Barrandei . .	..	..	..	..	..	..	..	..	×			
bohemicum . .	..	..	..	..	..	..	..	..	×	..	⊙	
vermiforme . .	..	..	..	..	..	..	..	×	×			
Nautilus												
bohemicus . .	..	..	..	..	..	×	×	×				
Holtianus . .	..	..	..	..	..	..	..	×				
quadrans. . .	..	..	..	..	..	×	×	×	×			
(*Trocholites*)												
anguiformis . .	..	..	×									
planorbiformis .	..	..	×	×	..	..	..	..	..	..	..	⊙
scoticus . . .	..	..	×	..	×							
Trochoceras												
remotum . .	..	×										
cinereum . .	..	..	×									
cornu-arietis. .	..	..	×	×	⊙							
asperum. . .	..	..	..	..	..	×	×	×	×?	..	⊙	
speciosum . .	..	..	..	..	..	×	×	×	..	..	⊙	
gyrans . . .	..	..	..	..	..	..	×					
regulare . . .	..	..	..	..	..	..	×					
tortuosum . .	..	..	..	..	..	..	..	×	..	..	⊙	
striatum . . .	..	..	..	..	..	×	..	×				
giganteum . .	..	..	⊙	..	..	×	×	×	..	..	⊙?	
rapax . . .	..	..	..	..	..	×?	..	×	..	..	⊙	
undosum . . .	..	..	..	×								
Lituites												
arietinus . . .	..	..	..	..	..	..	..	×	..	..	⊙	
ibex	..	..	..	..	..	..	..	×	×	×		
Ophidioceras												
articulatum . .	..	..	..	..	..	×	×	×				
geometricum. .	..	..	..	..	..	..	..	×				
Goniatites												
nautilaceum . .	..	..	..	..	..	..	..	×				
Total 142	2	10	39	11	15	43	35	65	39	7	32	6

GENERAL OBSERVATIONS.

The foregoing study naturally gives rise to certain observations, to obtain the power of making which is indeed the incentive to undertaking it. So far as a single group is concerned, we ought here to gain some insight into the laws which govern the appearance and disappearance of forms of life, and into the nature of those groups of individuals to which we assign the term "species." For this purpose, it may be well to draw up the following condensed table, showing the growth, culmination, and in some cases the decay, of the various genera and groups.

Table showing the Distribution of the Genera and Groups.

Genus or Group.	Tremadoc.	Llandeilo.	Bala.	Lower Llandovery.	Upper Llandovery.	Wenlock Shale.	Wenlock Limestone.	Lower Ludlow.	Upper Ludlow.	Tilestones.
Orthoceras . . .	1	9	25	7	11	29	15	31	31	6
Cyrtoceras . . .	1	?	6	1	2	4	3	8	2	..
Poterioceras . . .	..	..	2							
Gomphoceras . .	..	..	..	..	..	2	4	8		
Phragmoceras . .	..	..	1	..	1	1	5	3	1	
Ascoceras . . .	..	..	..	..	..	..	..	1	3	
Nautilus . . .	..	..	3	1	1	2	2	3	1	
Trochoceras . . .	..	1	2	2	..	4	5	6	?	
Lituites	..	..	..	..	..	..	..	2	1	1
Ophidioceras . .	..	..	..	..	..	1	1	2		
Goniatites . . .	..	..	..	..	..	..	..	1		
Conici	2	9	31	8	13	33	18	39	33	6
Inflati	..	..	3	..	1	3	9	12	4	
Spirales	..	..	3	1	1	2	2	3	1	
Irregulares . . .	..	1	2	2	..	5	6	11	1	1

We notice that there are two maxima, both in this table and in the more general one, corresponding respectively with the Bala and with the Lower Ludlow Beds. This fact is so general, and the reason sufficiently plain in the character and wide range of the beds, that we cannot conclude that there was a corresponding real falling off in the variety of forms between these two epochs. It is obvious however, from the fact that the species in the Wenlock Limestone are comparatively few when compared with those in the shales on either side of them, that the Cephalopods of those days were not commonly frequenters of clear and shallow waters, but were partly pelagic, and not uncommonly gregarious in more or less turbid waters.

Coming next to the groups, we see that the last-made observation is more especially applicable to the *Conici*, and that it was the more or less abnormal groups of the *Inflati* and *Irregulares* which could best abide the clearer waters of a coral reef. Of the four groups the *Conici* first appear, and form the bulk of the Lower Silurian fauna, the other groups making but little real show before the Upper Silurian period. The *Conici* and *Spirales* are the only two groups which continue to flourish in later periods. The *Inflati* have only a few representatives in the carboniferous *Poteriocerata*; the *Irregulares*, if occurring at all, being represented by different genera. These two groups must therefore be looked upon as offshoots from the main stem, which attained their maxima in the Lower Ludlow period, when the whole class were most flourishing, and then rapidly died away. We obtain from these facts independent confirmation of laws which appear to widely govern the development of life, and which may be thus stated :—

The simpler forms in a class are the first to be introduced, and the more complex appear later. It is only when the class is in its most flourishing condition, and not long before the close of a period, that it throws out the more remarkable and abnormal forms. The group which represents somewhat the mean of the whole and never attains an extraordinary abundance, as the *Spirales*, is the longest to last.

We must next consider the individual genera. The first to appear is *Cyrtoceras*, represented by the species *C. præcox*, though followed in the uppermost division of the same rocks by *Orthoceras sericeum*. It has been thought remarkable that the less simple form should precede the straight *Orthoceras*, but the history of discovery shows that we can place but little trust in such an isolated fact, which is liable any day to be reversed. Nevertheless, on any theory of evolution, the present state of the case is just what we might expect; for the lower groups from which the Cephalopoda might be derived are not straight, like an *Orthoceras*, but curved, like a *Cyrtoceras*: in fact, the absence of curvature is obviously only a particular case, while some amount represents the general idea. Moreover, if we are to look to individual development as the summing up of the history or ontogeny of the group, we should expect from the frequent curvature exhibited near the apex in the *Orthocerata* that their ancestors were curved.

Neither the first *Orthoceras* nor the first *Cyrtoceras* are transitional forms; both are well characterised. It is true that in neither is the siphuncle actually seen, but it is indicated; and it is only the state of preservation of the fossils that prevents us from seeing it better. Unless, therefore, we are prepared to believe that life in its various forms sprang into existence at the period in whose deposits we first find their remains, we must admit that there were Cephalopods during the oldest Cambrian or even the pre-Cambrian periods; and hence the fact of earlier forms being found in Sweden and England than occur in Bohemia loses

some of its significance, though we may still argue that where the group has been longest in existence there it will most abound, and the greater the abundance of individuals the greater is their chance of preservation in the rocks. And this observation loses none of its force when we notice that the comparative abundance of Cephalopods in the Bala Beds of Britain, in proportion to the whole number of Silurian forms, is much greater here than in Bohemia, where they swarm in Upper Silurian, but are very sparse in Lower Silurian times. Perhaps another proof of the earlier existence of the *Orthoceras* may be found in the fact that all the different groups, even the most ornamented, are pretty uniformly distributed throughout the series, and there is no apparent growth in complexity.

With regard to the genus *Cyrtoceras*, it is noticeable that the endogastric group antedates the exogastric. This is in harmony with the fact that the usually endogastric genus *Phragmoceras* antedates the usually exogastric *Gomphoceras*. With regard to the genus *Poterioceras*, the two species referred to it are so isolated that it may well be doubted if it be of any value. Nevertheless, we may notice that the forms of the *Inflati*, with imperfectly developed apertures, appear at the commencement and at the close of the range of that group, and may indicate a feebleness in its development. With regard to the *Inflati* generally, it is remarkable how short-lived they are, coming in with rapidity and soon being comparatively common forms, and then dying out suddenly and finally. Such great differences in the history of one group as compared to another must surely indicate the action of some peculiar cause which does not affect all groups alike. The position assigned to the genus *Ascoceras* in the present work is consistent with their brief and late period of existence, but any other position would not be.

The same remark as to the endogastric forms preceding the others of the same genus is true of the *Nautilus*, the only Lower Silurian species of which belong to the subgenus *Trocholites*, with the siphuncle internal. Again and again does the *Nautilus* appear to have tried this position in *Trocholites*, in *Clymenia*, and in *Aturia*, and each time it has been a failure; the external siphuncle has been equally wanting in success.

Of the other genera, the *Trochoceras* has the longest range, though represented by different species in Upper and Lower Silurian rocks; but none of these call for any special remark.

We come now to the "species." It is inevitable, in any profitable description of a great group of life-forms, that we should make use of the specific nomenclature, and limit each individual studied to the use of one or other of the names employed, and thus assume at least the existence of definite groups, cut off from all around them. This very necessity of description, however, relieves the describer from having thereby expressed any opinion as to whether any such groups really exist. The old idea of the independence of species—and their only, so to speak,

fortuitous resemblance to those most nearly allied to them—rests, when truly examined, on no more rational foundation than the more recent and diametrically opposite opinion. I say "opinion" advisedly, for there is proof on neither side; but prejudices derived from other things than science have been in favour of the first, and every prejudice derived from the study of life itself is in favour of the last. It is for this reason that I have adopted the method of describing actually, not a species, but a single type specimen, round which the other individuals designated by the same name may cluster as closely as they can. In attempting to explain as best we may the undoubted phenomenon of distinct specific groups at the present day, we have practically two theories to choose from—that which considers each species a special creation, or which at least considers them real though inexplicable; and that which asserts the development of one from the other by a process of evolution. In deciding between these, an appeal is made to Palæontology to show, if it can, the gradations between one species and another; and at the close of such a study as the present, the author may well be asked, what is his result from this point of view? In reply, I must state that if species were such definite entities as they were once supposed to be, they ought to be much more easily distinguished than they are; and the many variations of form which will be found included, and necessarily included, under one specific title, whose "general description" thereby becomes one of considerable latitude, show that different specimens are either not so closely linked as that theory would imply, or else that we ought to adopt many more "species," in many cases one for each individual. The present study is therefore all against fixity of species. Does it, on the other hand, give any positive aid to the theory of evolution? In considering the true answer to this question, it must be observed that everything which renders the independence of specific forms improbable, in exactly the same proportion makes their dependence probable. If, therefore, the wide variations which are here noted from any specific type renders the fixity of species in any sense improbable, they so far teach that one type is derived from the other. The two views of their origin are, in fact, mutually exclusive. Farther than this it is not very safe to go; for, among the many forms which flourish in any one epoch, it is impossible to say with certainty which was the descendant of any particular form in the preceding epoch, especially as the intervening links are in all probability absent. It would not be difficult to pick out a series which *may* have been produced by descent. Thus *Orthoceras coralliforme* of the Bala period might, by loss of transverse ornaments, turn into *Orthoceras Bacchus*, which first appears in the Llandovery, and has transverse ornaments in youth; and this again might change by the longitudinal ornaments becoming all equal, as they begin to be in old age, into *Orthoceras filosum*, which is not found for certain below the Wenlock Beds. But there is no proof that this series is actually so connected, and there are many isolated forms whose ancestors and descendants are alike

obscure. When our ignorance of the actual course of development, on the supposition of its having taken place, is duly allowed for, none of the facts observable in the present study, at least, make in any way against the general theory of evolution. We find it impossible to say that any one position of the siphuncle, or one style of ornament, indicates an advance upon any other, and the assumption of such being the case may easily be made the basis of apparent contradictions. But while the general history has been one of advance, we have no right to expect the same to be obvious when we come to smaller groups. Yet, taking the four groups into which I have divided the Nautiloidea—the *Conici*, the *Spirales*, the *Inflati*, and the *Irregulares*—of the first two, which may be considered the simpler, 44 per cent. occur in the Lower Silurian; while of the two latter, which are more specialised, only 18 per cent. are found in the earlier rocks. So also, among the *Orthocerata*, the Lower Silurian forms are either for the most part the simpler, or have large siphuncles, which is exactly the opposite to the final character of that organ in the class. So, too, amongst *Nautilus* the earliest forms have an internal siphuncle, while the opposite position is the finally dominant one in the class. The age of the genus *Ascoceras* also, when that is rightly placed from purely zoological considerations, is not a difficulty in the way of evolution, as Barrande supposed it, but it occupies its natural place.

To the general theory of evolution, therefore, which merely states that every form of life has been developed from a preceding one nearly allied to it, the present study affords no contradiction or difficulty, but affords aid, if not as great as could be desired, yet as much as could be expected.

With regard to any particular method of evolution, such as that known as "natural selection," the case is different. We have under view in the present study a fair representative of successive fauna of the same class, and the history of the class must at least be feebly written here. Yet while we do not find the forms rigidly bound within "specific" limits, they do not appear to be scattered haphazard over the whole range of possible varieties, but are remarkably grouped round a series of central types. Now, so long as the environment remains constant, the process of evolution by indefinite variation and survival of the fittest should either be uniform and leave relics having no special grouping, or it should cease when the best adaptation to the environment had been acquired. In the first case, the arrangement of the fossils in even nominal "species" would never have been suggested. In the second case, all variety must depend on change of environment. If this change, again, had been approximately uniform, the same result as in the first case would be brought about; and if it had been sufficiently rapid to produce a species, all the forms of life must have been more or less affected by it, and such changes ought to be marked by an extensive divergence of fauna. Such is not

observable in the Silurian period, at least. There are changes of fauna indeed, but they are more or less gradual. The argument from the imperfection of the geological record is of little avail; for the number of individuals found, which range themselves round specific centres, even counting all those of one locality as a single individual, is sufficient to render the probability that such centres exist very much greater than that the series from which these terms were selected at random should be uniform.

The great defect of the theory of natural selection is that it leaves the original variation, which is the basis of the whole, to chance; chance variations are not likely to lead to any *law*, yet there are several well-marked laws in the progress of the various forms of life. The part which it has effectually performed is to show how variations of the individual may produce permanent changes in the species, and thus to break down the idea of the fixity and independence of the latter. The chance variations were appealed to in the proof as illustrations, and have been assumed to be the kind actually operating, but there is not the slightest evidence that an indefinite change from species to species may be brought about by this kind of variation. We are perhaps as yet too dazzled by the brilliancy of the theory to perceive its inadequacy as a complete account of life, or to place it as one link only in the chain of explanation.

The whole of the facts of embryology teach us to look to the development of the individual from the ovum to the perfect animal as the summing up of the history of the species in its evolution from the lowest forms, and to my mind the only adequate account of the evolution of the whole animal kingdom is derived from the same analogy more fully carried out. Only superficial differences can be perceived in the ova of very different animals, yet each goes forward to its perfection along perfectly marked lines. If, for example, it be the ovum of a bird, there is no attempt (as far as we can tell) to try various kinds of development, as of a reptile or of a mammal, and to select the birds as the fittest; but the ovum contains in its essence all the future features of the adult, to the paintings on its plumage and the pattern of its comb. Chance variations and natural selection have no place in these larger matters, though minor details, say of colour, may depend on the relative size of capillaries, itself depending on the chance development of the cells. This individual development along predetermined lines is due, according to the theory of natural selection, to heredity — or the property which the ovum possesses of reproducing not only the character of the parents, but the history of their evolution. It is admitted, therefore, that the ovum has *some* properties, however derived, which cause it to develop in a certain way, and this would be equally true if we were (as we are) ignorant of their mode of derivation.

So in the evolution of life. The first living animal, though apparently (could we have seen it) only a speck of protoplasm, contained not only the potentiality, by small variations and natural selection, of all future forms, but the very essence of those forms, all of which have followed as necessarily, and by the same kind of power, as that which produces an individual from an ovum.

Whether the development of life as a whole is due to heredity, as that of the individual is supposed to be, and we are to conceive of an anterior series of organic forms of the perfection of which the present organic kingdoms are the offspring, or whether the whole series owes its development to some inherent property which differs from "heredity" only in not requiring the pre-existence of a similar though less advanced series, is a question towards answering which we have not the slightest information.

The characters of the adult are often very different from those of the young, so different in some cases that the stages through which the latter pass have been placed in distinct genera; and if we define an "individual" as the result of a single impregnated ovum, we have to include several generations under that title. Such a series is but a feeble representative of the whole animal kingdom, which in the same sense may be considered as but a single individual.

Comparing this with the theory of natural selection, we find it in some respects to stand upon the same level in logic. In one case we *know* that by small variations, with the aid of natural selection, dependent on the environment, permanent varieties, if not species, may be produced, and we *theorize* that the whole animal kingdom has been brought about in this way. In the other case we *know* that a simple-looking ovum develops without the aid (to any appreciable extent) of natural selection, and independently to a great extent of the environment, through a series of successive forms, and we *theorize* that all the separate species, genera, and classes have been formed in the same way by the development of the primordial ovum—the ovum of life—which contained all these properties in itself.

In other respects there is an advantage in its favour, for the essence of an explanation is the reduction of the number of marvels; and in the theory of natural selection there is one marvel as to how, say, a feather could be produced by chance variations, and another as to how that feather is contained in the essence of the egg. But by the theory now discussed, there is but one; for the original formation and the constant reproduction are the same thing.

From this point of view the *Gomphoceras*, *Ascoceras*, *Trochoceras*, &c., which appear for a time and then are lost, are like the temporary processes of a Pluteus, which form no part of the adult echinoderm. So the development of any group of life-forms at periods out of the strict order of advance, as far as we can see, is com-

parable to the occasional differentation in some animals of organs considered high in the scale at various stages of its life-history. This theory allows us to account for the rapid progress of life at the first, and its varying progress later, and explains, by the co-adaptation of organs in the animal, the co-adaptation of various animals to each other; but, above all, it shows an analogy, in the rapid development of particular parts at definite times of life, with the introduction of species on the globe, which, like the material of the organ, have sprung from previously formed material.

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Plate I.

Fig.

1. Nautilus pompilius in its shell (after Valenciennes, reduced). *a*, the hood; *b*, the "tentacles"; *c*, their sheaths; *d*, the eye; *e*, the front part of the mantle; *f*, the hinder part of the same; *g*, the band of adhesion; *h*, the protrusion caused by the nidamental glands in the female; *i*, vascular marks in the mantle; *k*, the septa; *l*, their "necks"; *m*, the siphuncle.
2. The circulatory and respiratory organs (after Owen, but reversed and reduced). *a*, the great vein; *b*, its perforations; *c*, the common sinus; *d*, the branchial arteries; *e*, their follicles; *f*, two of the branchiæ; *g*, their stem; *h*, the branchial veins; *i*, the systemic heart; *k*, the siphonal artery; *l*, the great aorta.
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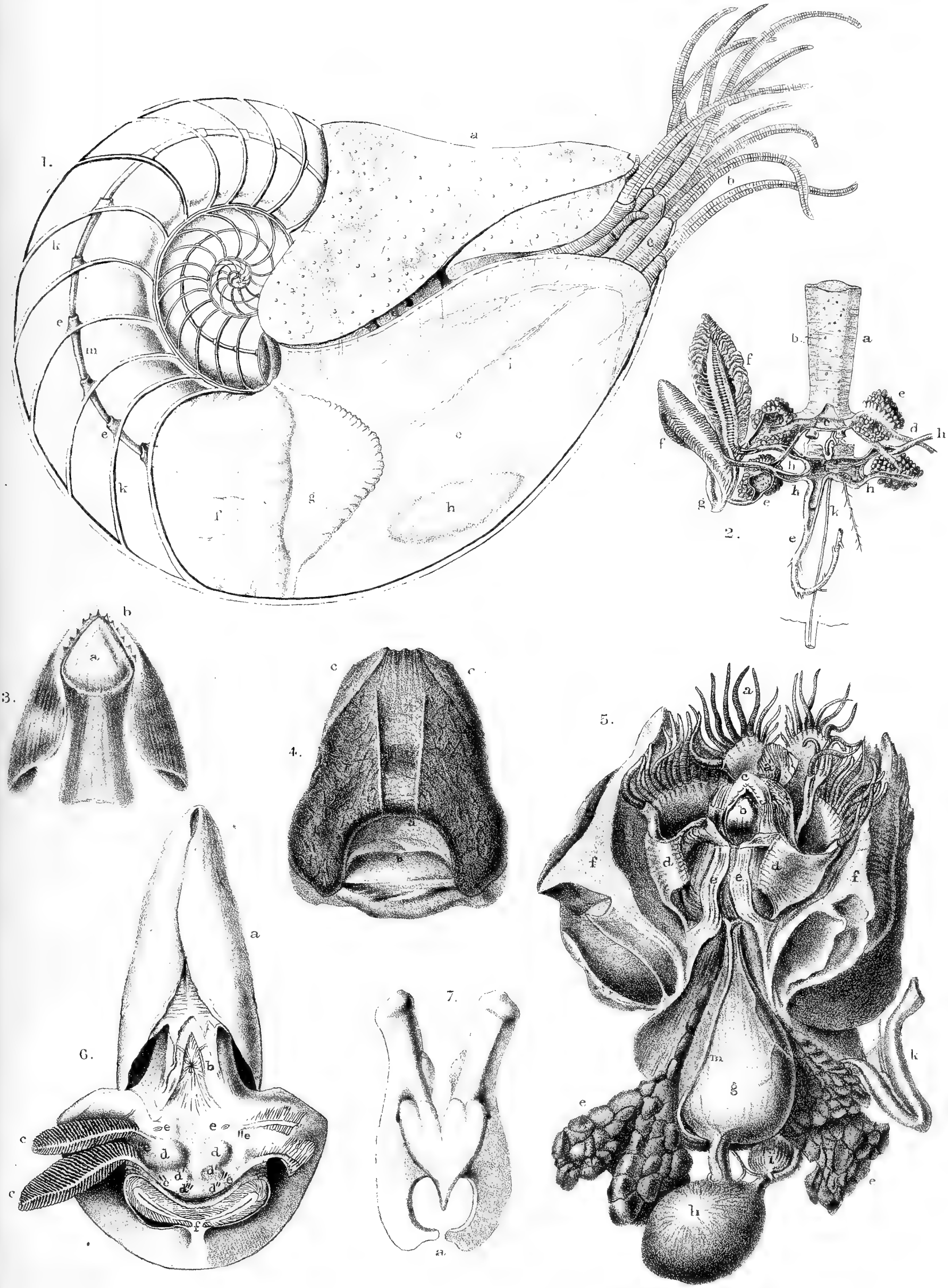

A. Gawan, del et lith.

Mintern Bro's imp.

Plate II.

Fig.

1. Nautilus pompilius.—A vertical section through the inner and outer shell, and a septum. *a*, the outer, *b*, the inner layer of the outer side of the shell; *c*, the black deposit made by the succeeding whorl; *d*, the outer, *e*, the inner layer of the inner side of the succeeding whorl; *f*, the thin lining of the shell; *g*, the deposit in the corners of the septa; *h*, the septa. (× 15.)
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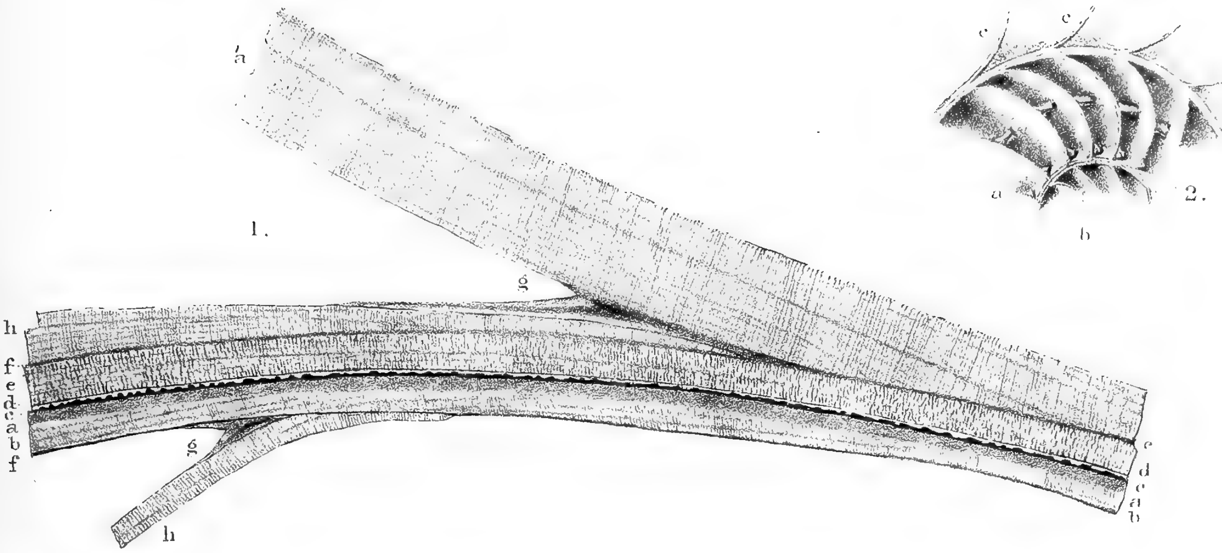

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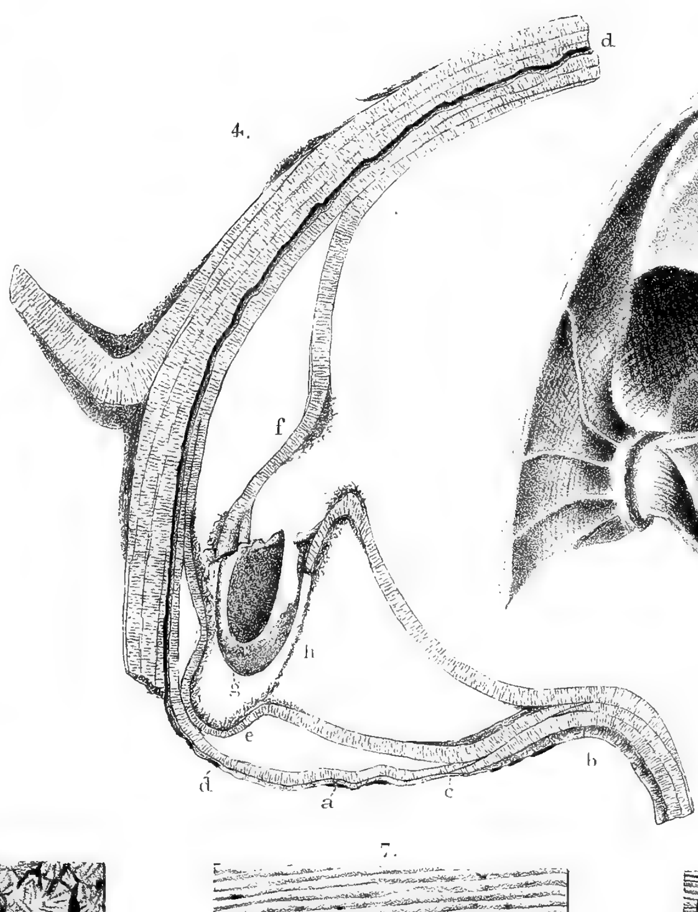

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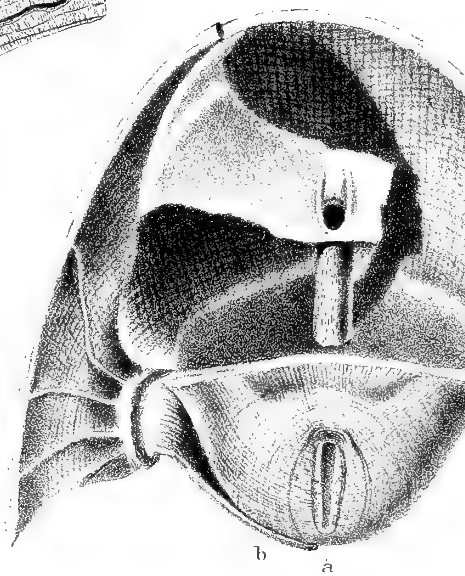

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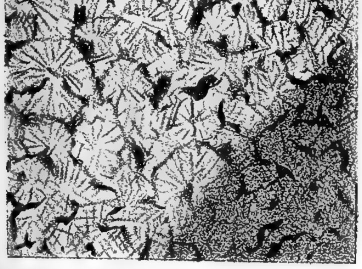

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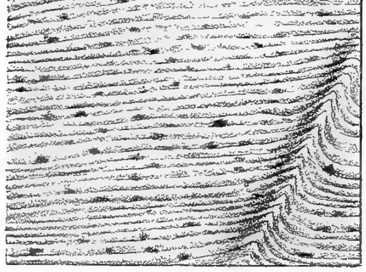

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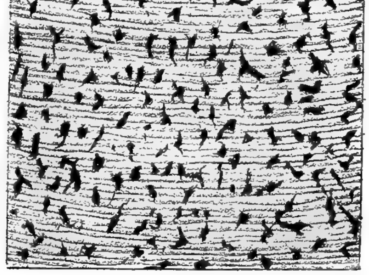

A. Gawan, del et lith.

Minterr. Bro's imp.

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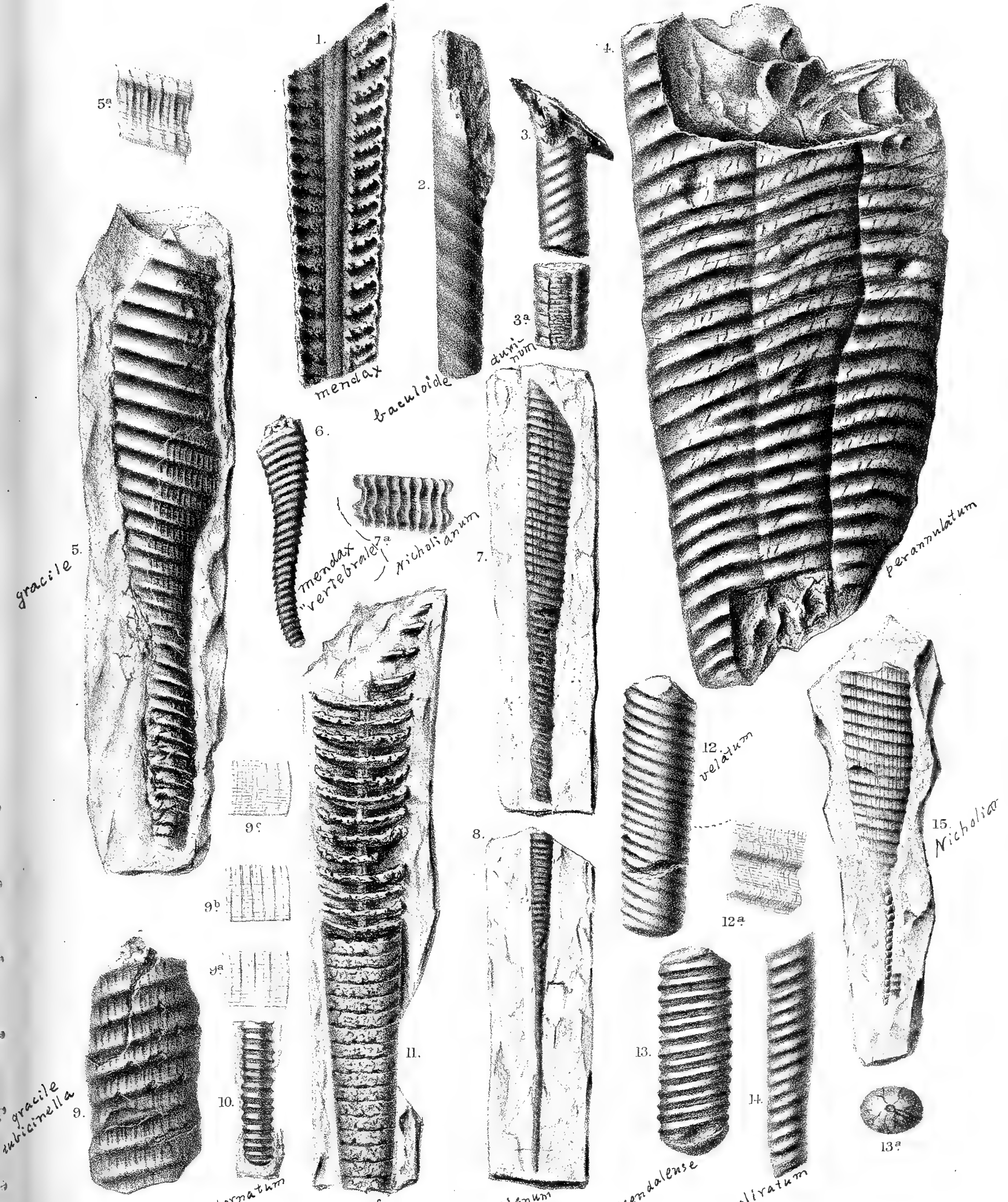

A. Gawan, del et lith.

Mintern Bro's imp.

Plate IV.

Fig.

1. Orthoceras annulatum.—From the Wenlock Limestone, Dudley. In the Woodwardian Museum.
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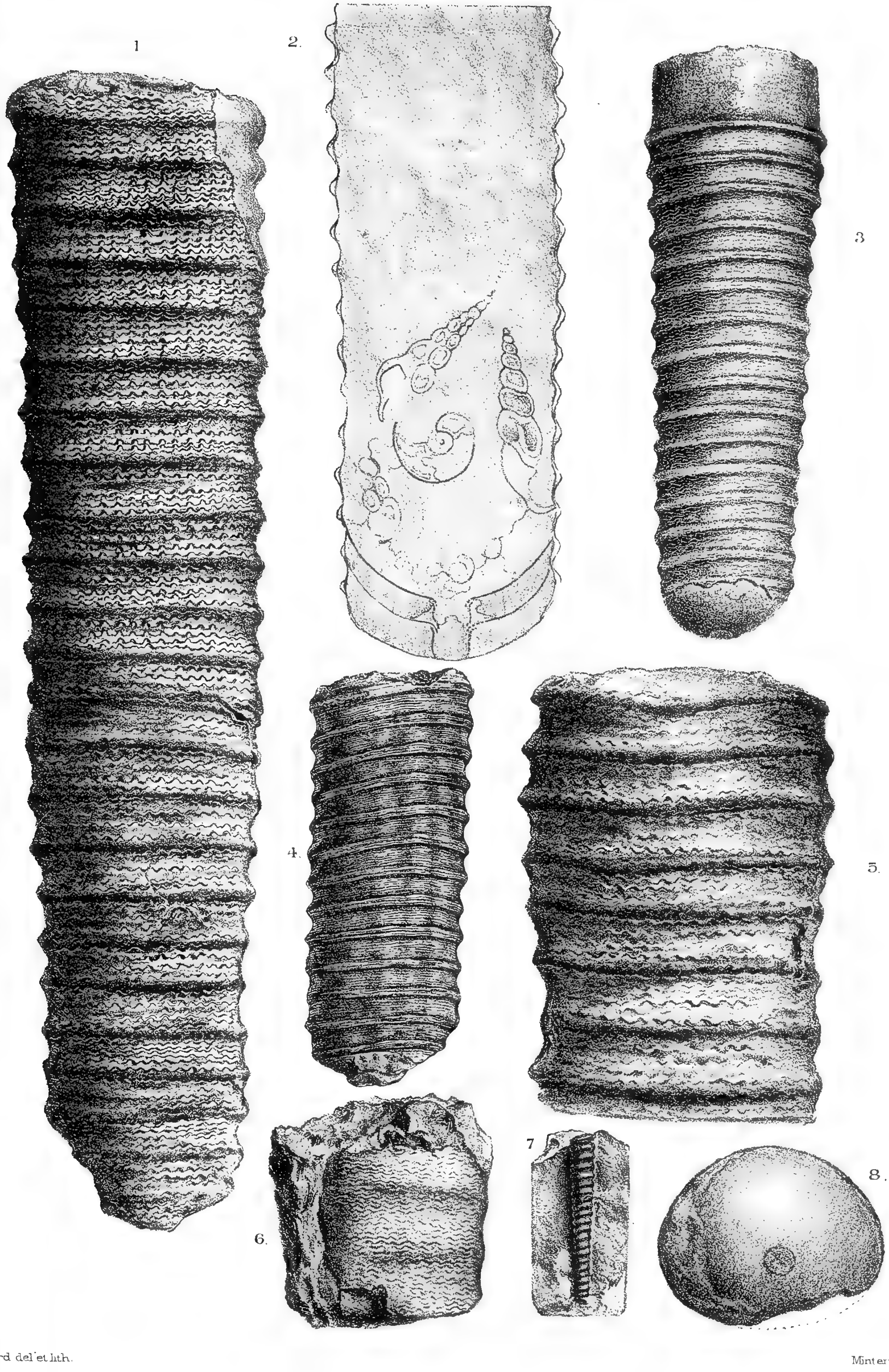

A S Foord del et lith.

Mintern Bros. imp

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1. Orthoceras Duponti.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, the surface magnified.
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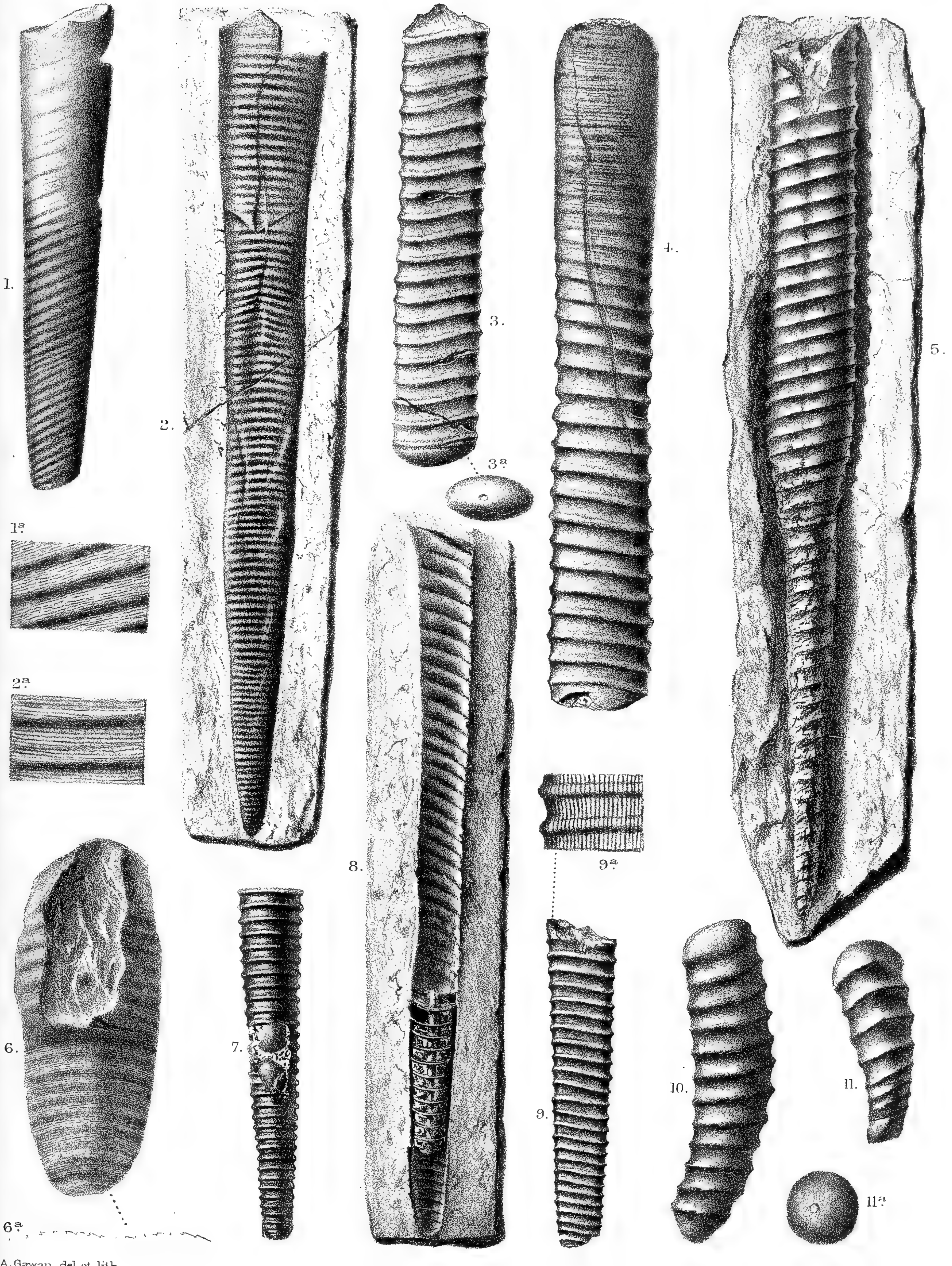
11. *Ibid.*—From the same locality and collection. (The drawing also reversed.) *a*, the septal surface.



A. Gawan, del. et. lith.

Mintern Bro's imp.

Plate VI.

Fig.

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2. *Ibid.*—From the same locality and collection. Possibly part of the same specimen as fig. 1.
3. Orthoceras Etheridgii.—From the Wenlock rocks of Raeberry Castle, Kirkcudbright. In the Museum of the Geological Survey, Edinburgh.
4. *Ibid.*—From the same locality and collection. A section showing the true form of the septal surface.

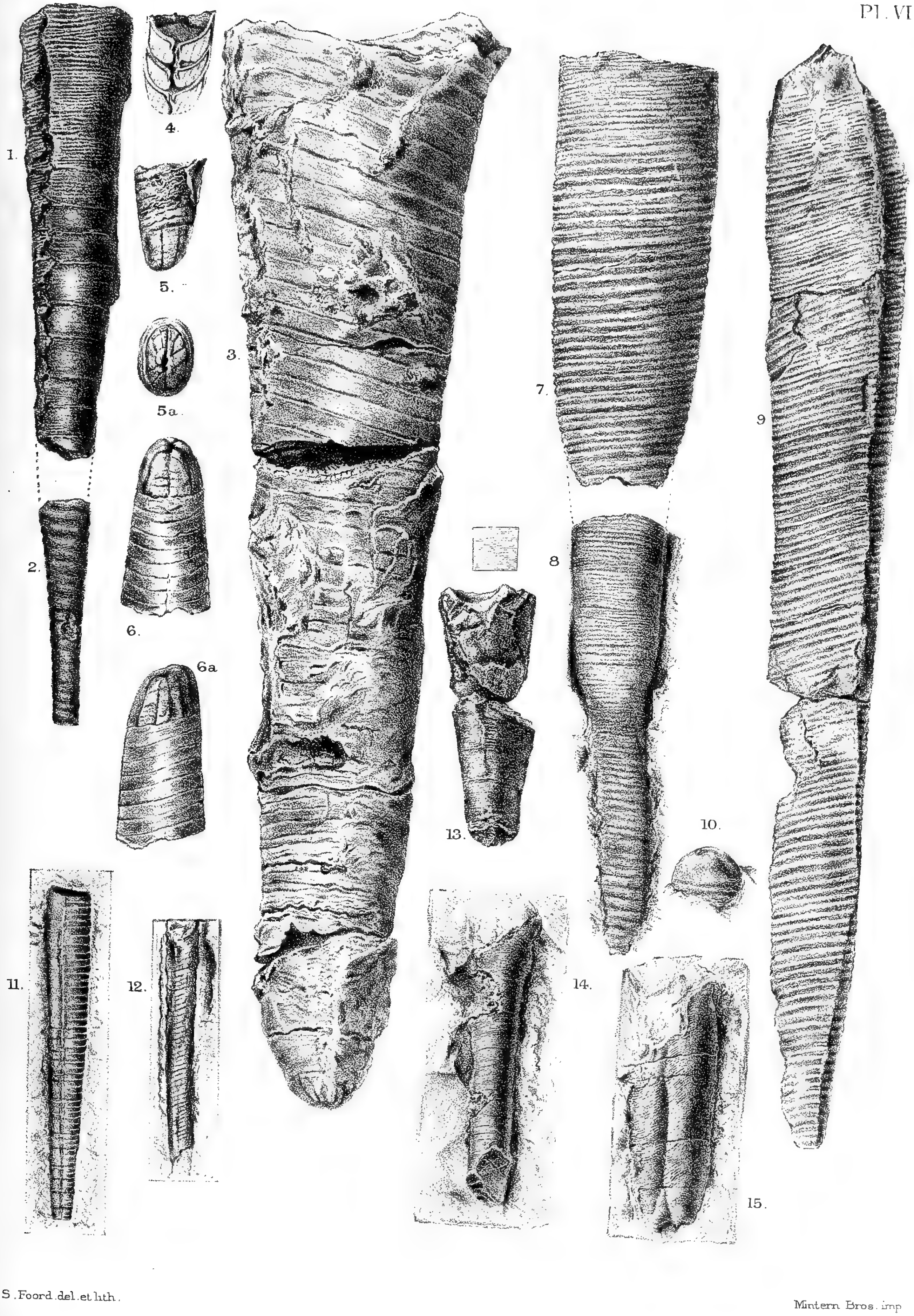
5, *5a*. *Ibid.*—From the same locality and collection. Showing the hollow at the apex, and the form of the pseudoseptal surface.

6, *6a*. *Ibid.*—From the same locality and collection. Showing the folds on that surface.

[These figures are from drawings kindly supplied by Mr. C. W. Peach.]

7. Orthoceras Maclareni.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
8. *Ibid.*—From the same locality and collection, but not the same specimen.
9. *Ibid.*—From the Upper Silurian, Pentland Hills. In the Museum of Practical Geology. The typical form.
10. *Ibid.*—From the same locality and collection. Showing the septal surface.
11. Orthoceras dimidiatum.—From the Lower Ludlow, Leintwardine. In the Woodwardian Museum. With upward imbrications. External cast.
12. *Ibid.*—From the Lower Ludlow, Kington. In the Museum of Owens College, Manchester. Showing downward imbrications.
13. Orthoceras argus.—From the Wenlock Shale, Kingswood Fordon. In the Museum of Practical Geology.
14. *Ibid.*—From the Middle Bala, Holbeck Gill. In the Museum of Practical Geology.
15. Orthoceras expansum.—From the Bala Beds, Desertcreat. In the Museum of Practical Geology.

Pl. VI.



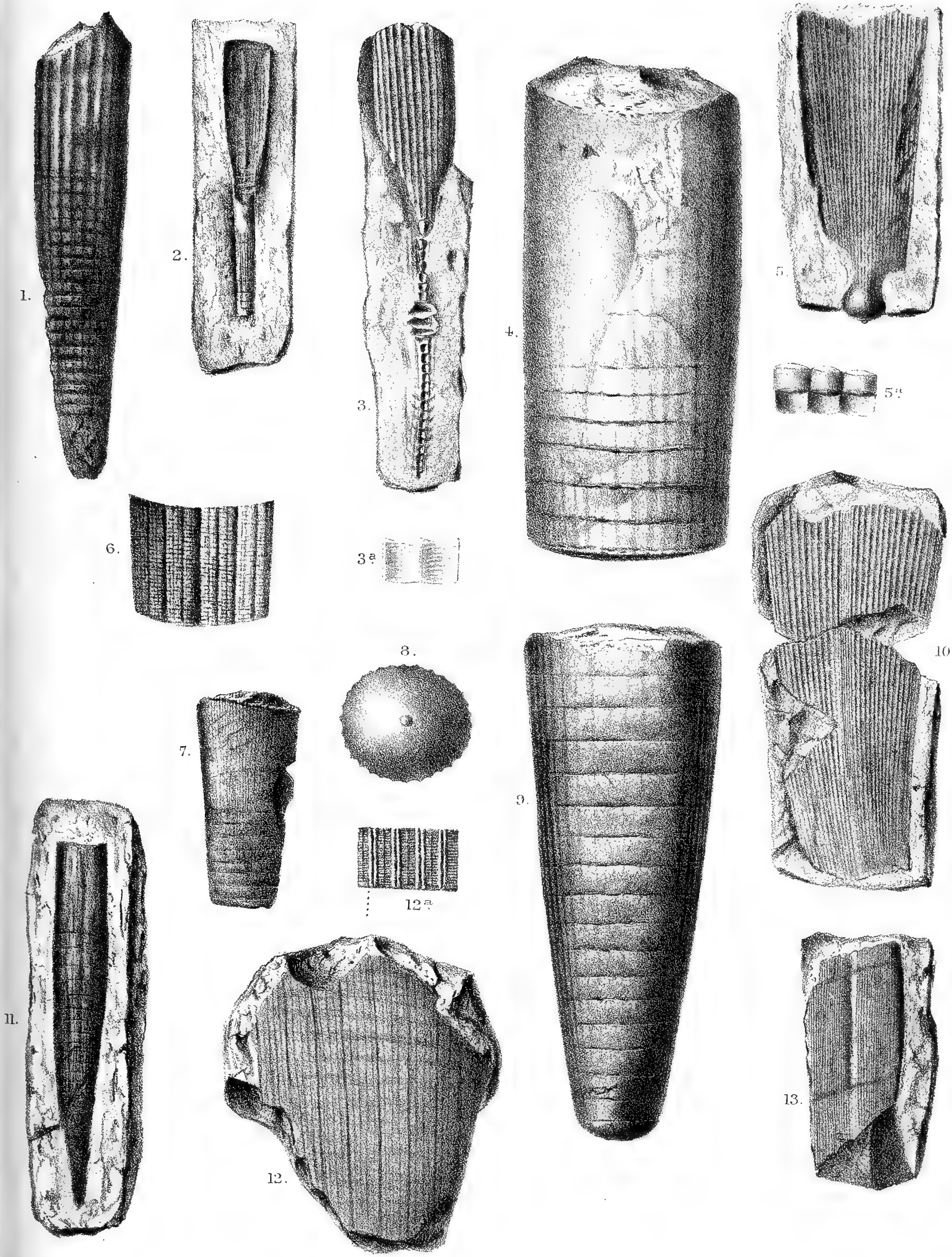
A. S. Foord del. et lith.

Mintern Bros. imp.

Plate VII.

Fig.

1. Orthoceras angulatum.—From the Upper Ludlow, Shropshire. In the Museum of Practical Geology.
2. Orthoceras lineatum.—From the Bala Shales, Desertcreat. In the Museum of the Royal College of Science, Dublin.
3. Orthoceras angulatum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. Showing the form of the siphuncle. *a*, the minor ornaments magnified.
4. *Ibid.*—From the Wenlock Limestone, Dudley. In the Woodwardian Museum. The largest met with.
5. Orthoceras originale.—From the Wenlock Shale, Builth. In the Museum of Practical Geology. *a*, enlarged figure showing the biconvex shell.
6. Orthoceras coralliforme.—From Bala Beds, Piedmont Glen, Ayrshire. In the Museum of Practical Geology. Part of an external cast.
7. Orthoceras lineatum, var. tenuistriata.—From the Upper Llandovery, Marshbrook. In the Museum of Practical Geology.
8. Orthoceras angulatum.—From the Wenlock Limestone, Donnington Wood. In the Museum of Practical Geology.
9. *Ibid.*—From the same locality and collection as fig. 4, giving with that an idea of the size.
10. Orthoceras originale.—From the Wenlock Shale, Builth. In the Woodwardian Museum.
11. Orthoceras lineatum.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology.
12. Orthoceras filosum, var. spectanda.—From the Wenlock Limestone, Ledbury. In the Museum of Practical Geology. *a*, the surface magnified.
13. Orthoceras lineatum, var. tenuistrata.—From the Wenlock Shale, Builth. In the Museum of Practical Geology.



A. Gawan, del et lith.

Mintern Bro's imp.

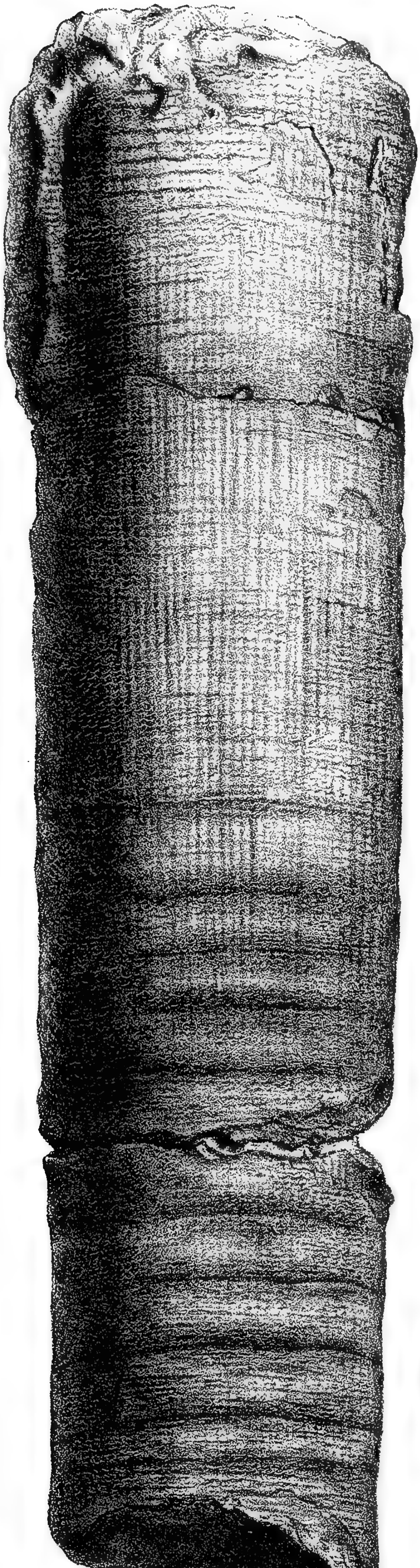
Plate VIII.

Fig.

1. Orthoceras fimbriatum.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod. Showing the aperture.
2. *Ibid.*—From the Wenlock Limestone, Eastnor. In the collection of Dr. Grindrod. A siphuncle like those usually called *O. Brightii.*
3. *Ibid.*—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod. A variety with coarser fimbriæ, and showing bands of colour.
4. Orthoceras annulatum.—From the Wenlock Limestone, Eastnor. In the collection of Dr. Grindrod. Showing a peculiar form of septal surface.

Pl. VIII.

1.



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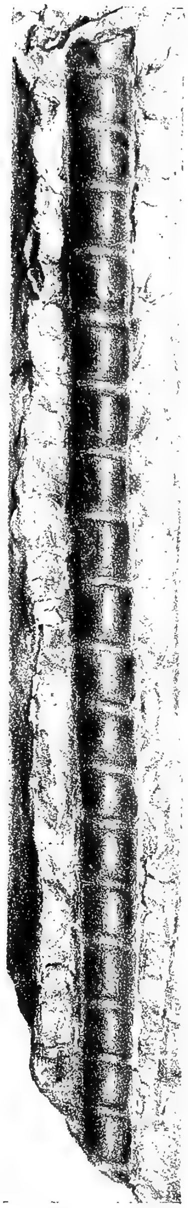

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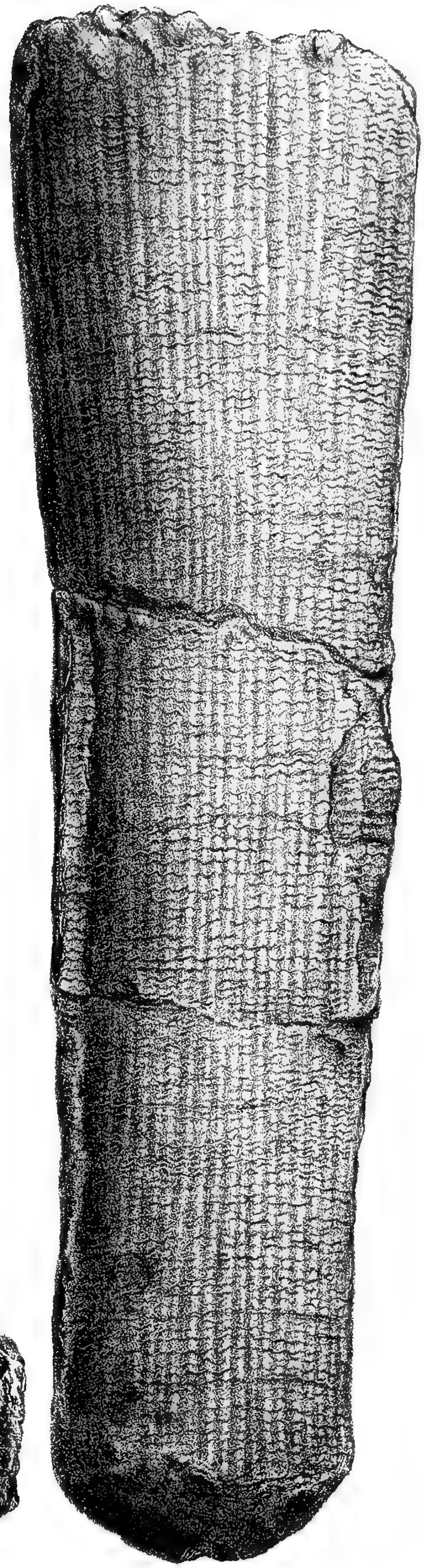

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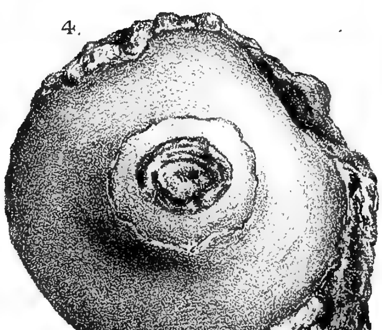


A.S Foord del. et lith.

Mintern Bros imp.

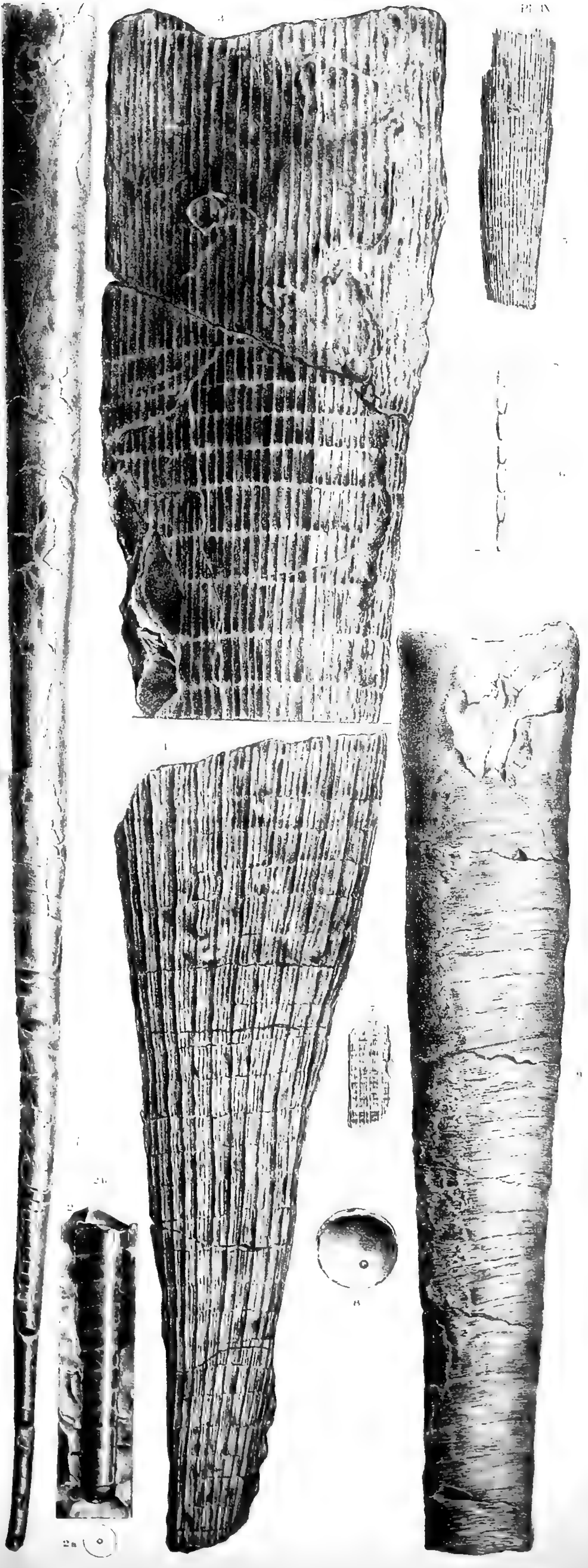
Plate IX.

Fig.

1. Orthoceras politum.—From the Bala Series, Glenwhapple. In the Woodwardian Museum. Perhaps M'Coy's type.
2. *Ibid.*—From the same locality and collection. *a*, diagram showing the position of the siphuncle at the small end; *b*, showing its position at the large end.
3. Orthoceras Bacchus.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
4. *Ibid.*—From the Wenlock Shale, Usk Tunnel. In the Museum of Practical Geology.
5. *Ibid.*—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. Showing finer ornaments when young.
6. *Ibid.*—Diagram to show the form of the elements of the siphuncle. From a specimen in the same collection.
7. *Ibid.*—From the Lower Ludlow, Dudley. In the Woodwardian Museum. A very ornamented fragment, showing transverse folds.
8. Orthoceras politum.—From the Bala Series, Glenwhapple. In the Museum of Practical Geology. Showing the unsymmetrical siphuncle.
9. Orthoceras Grindrodi.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.

Pl. IX.

1



A. S. Foord del. et lith.

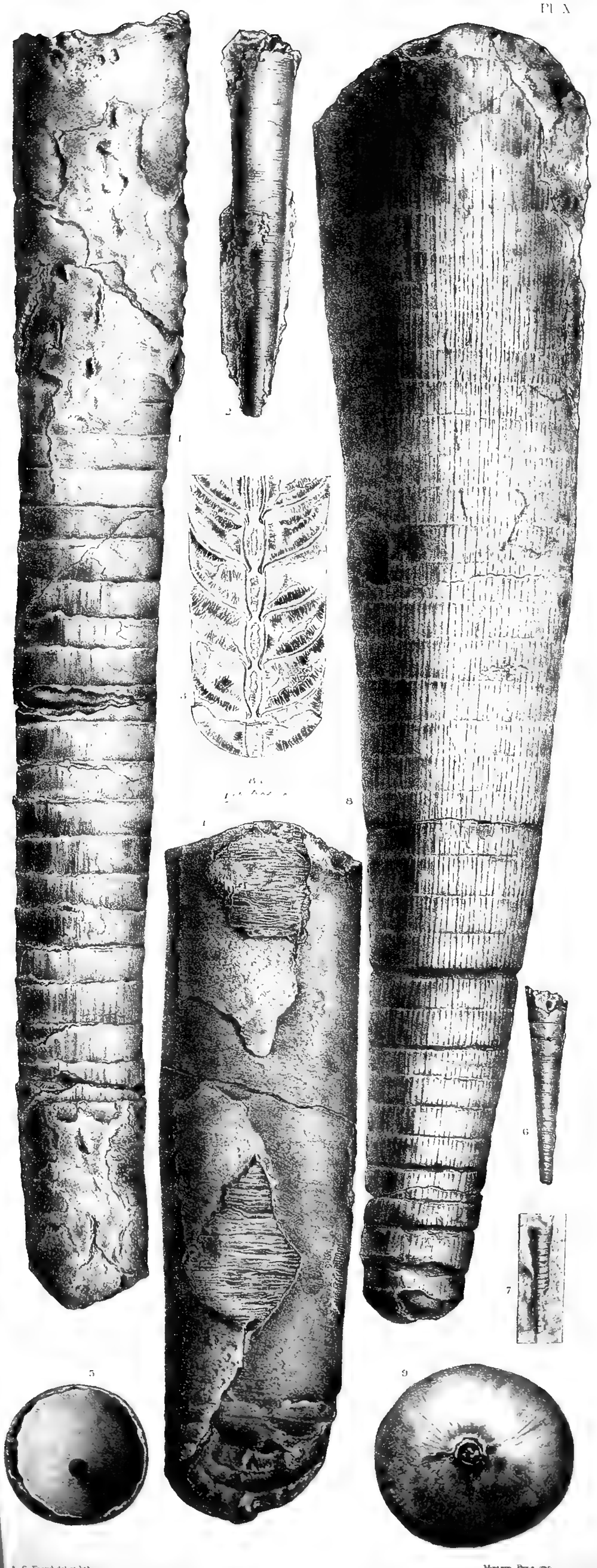
Mintern Bros. imp.

Plate X.

Fig.

1. Orthoceras ludense.—From the Wenlock Beds, Dudley. In the British Museum.
2. Orthoceras mocktreense ?—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
3. Orthoceras ludense.—From the Lower Ludlow, Herefordshire. In the British Museum. Showing the internal structure.
4. *Ibid.*—From the Lower Ludlow, Ludlow. In the Museum of the Geological Society. Showing the aperture.
5. *Ibid.*—From the Lower Ludlow, Leintwardine. In the Woodwardian Museum. Showing an unsymmetrical siphuncle.
6. Orthoceras mocktreense ? (young.)—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
7. Orthoceras ludense.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod.
8. Orthoceras filosum.—From the Lower Ludlow, Mocktree. In the Ludlow Museum. *a*, a section through the shell to show the uprightness of the riblets.
9. *Ibid.*—From the Lower Ludlow, Leintwardine. In the Museum of Practical Geology.

Pl. X



A. S. Foord del. et lith.

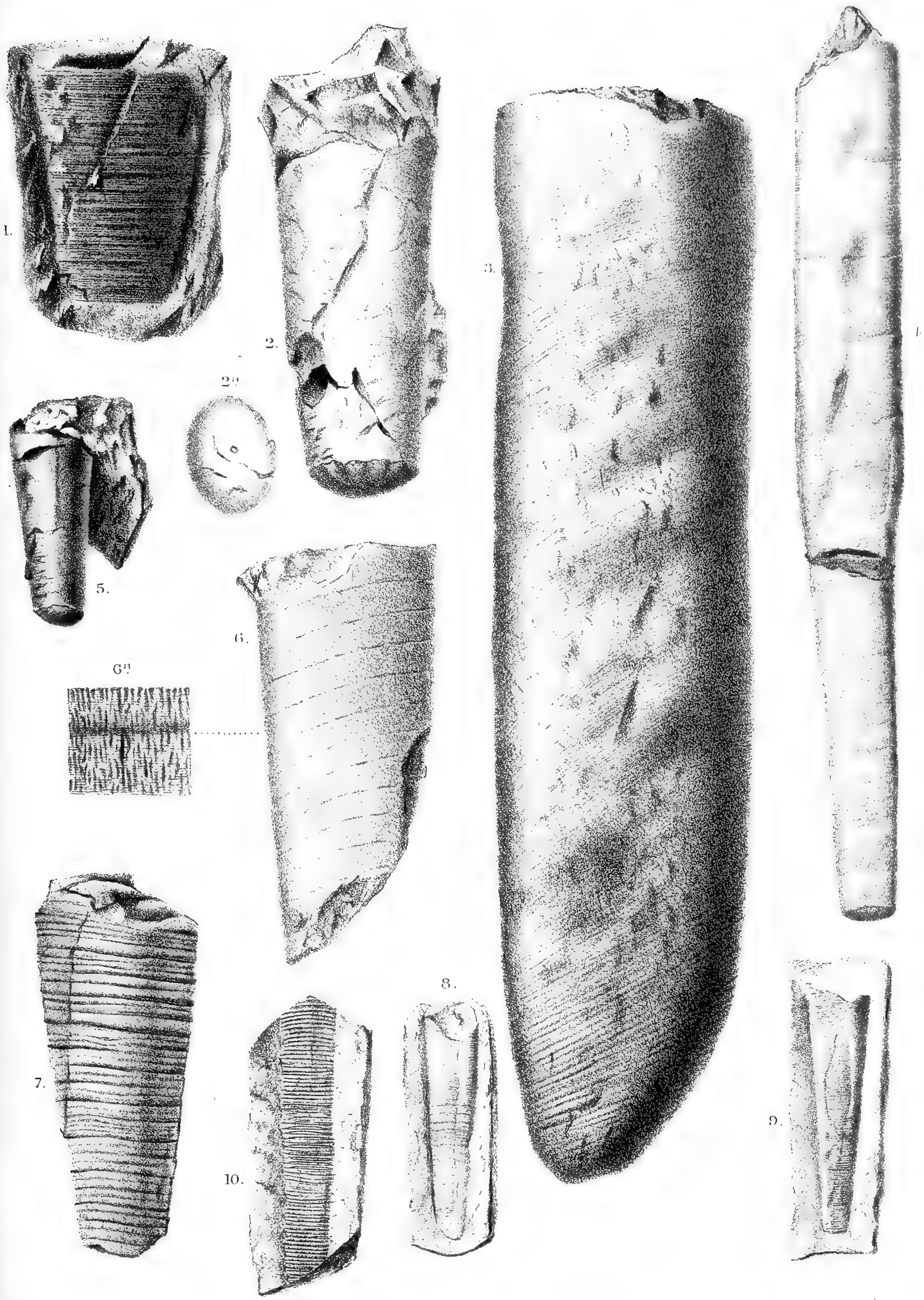
Mintern Bros. imp.

PLATE XI.

Fig.

1. ORTHOCERAS POMEROENSE.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology.
2. ORTHOCERAS PENDENS.—From the Bala Beds, Broughton. In the Museum of the Geological Survey of Scotland. *a*, the septal surface of the same.
3. ORTHOCERAS MOCKTREENSE ?—From the Lower Ludlow, Mocktree. In the Museum of Practical Geology.
4. ORTHOCERAS RECTICINCTUM.—From the Upper Ludlow, Ludlow. In the Ludlow Museum.
5. ORTHOCERAS PENDENS.—From the Bala Beds, Broughton. In the Museum of the Geological Survey of Scotland. Showing the ornaments.
6. ORTHOCERAS SATURNI.—From the Lower Ludlow, Leintwardine. In the Museum of Practical Geology. *a*, the surface magnified.
7. ORTHOCERAS REVERSUM.—In the Museum of Practical Geology. Horizon unknown, but the matrix looks like the Ludlow Mudstones.
8. ORTHOCERAS SUBUNDULATUM.—From the Wenlock Shale, Barrington. In the Museum of Practical Geology.
9. *Ibid.*—From the same locality and collection.
10. *Ibid.*—From the Wenlock Shale, Builth. In the same collection. A flattened surface, the appearance of which may be due to pressure.

Pl. XI.



A. Gawan, del et lith.

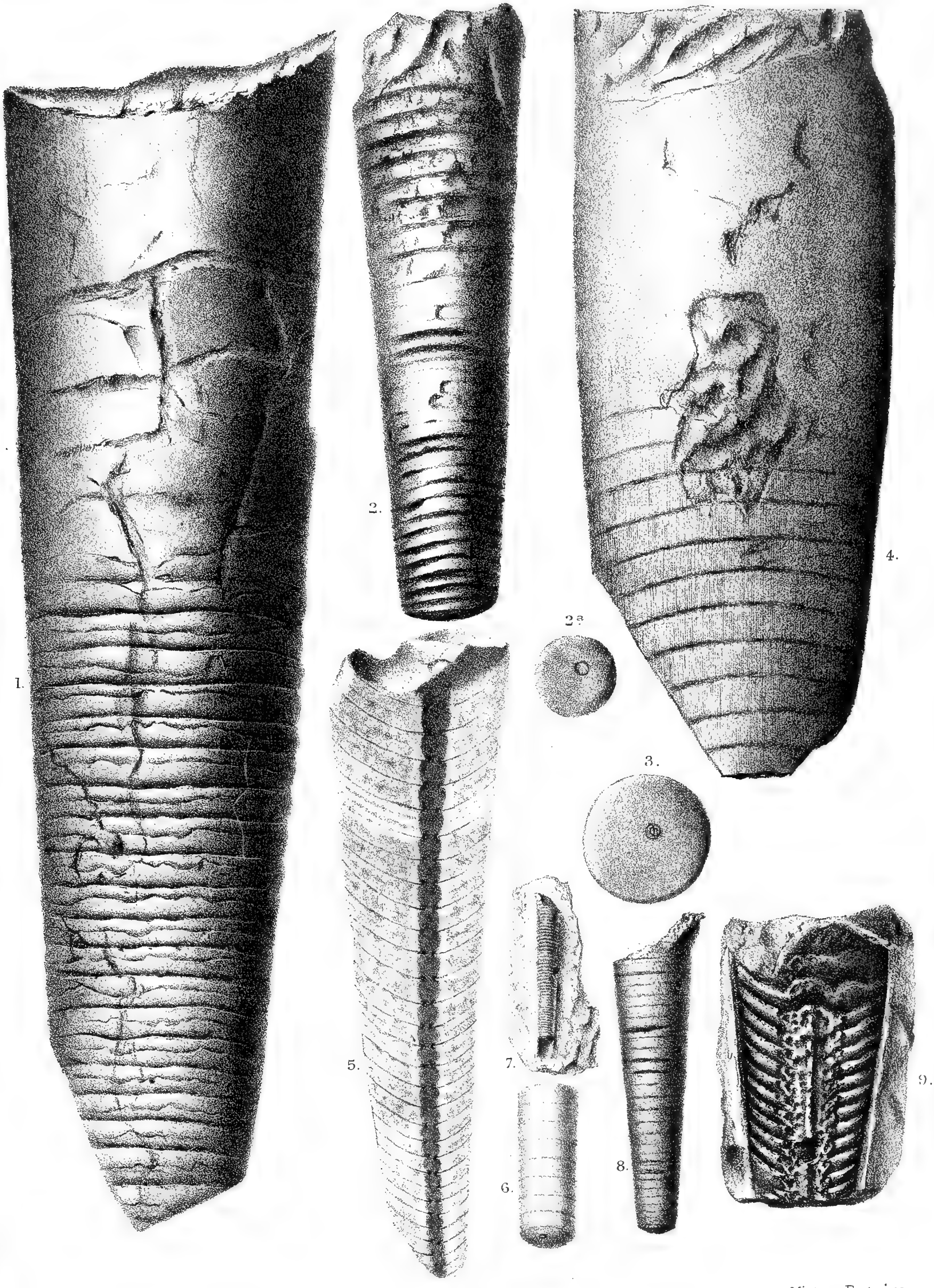
Mintern Bro's imp.

Plate XII.

Fig.

1. Orthoceras ardvellense.—From the Bala Series, Ardwell. In the Museum of Practical Geology.
2. Orthoceras excentricum.—From the Wenlock Shale (?), Clytha, Usk. In the Museum of the Cardiff Naturalists' Society. *a*, end view of septal surface.
3. *Ibid.*—End view of Sowerby's type. From the Wenlock Shale, Radnor. In the Museum of the Geological Society.
4. Orthoceras bullatum.—From the Upper Ludlow, Ludlow. In the Ludlow Museum. Example showing striæ.
5. *Ibid.*—From the Aymestry Limestone, Ledbury. In the collection of Dr. Grindrod. Section showing the septa. This example is ornamented with riblets.
6. Orthoceras subgregarium.—From the Bala quartzites, Cong. A copy of M'Coy's figure.
7. Orthoceras ascendens.—From the Bala Limestone, Chair of Kildare. In the Museum of Practical Geology.
8. Orthoceras audax.—From the Bala Beds, Rhiwlas. In the Museum of Practical Geology.
9. Orthoceras subconicum.—From the Upper Llandovery, Tortworth. In the Museum of the Geological Society. Sowerby's type of *O. conicum*.

Pl. XII.



A. Gawan, del et lith.

Mintern Bro's imp.

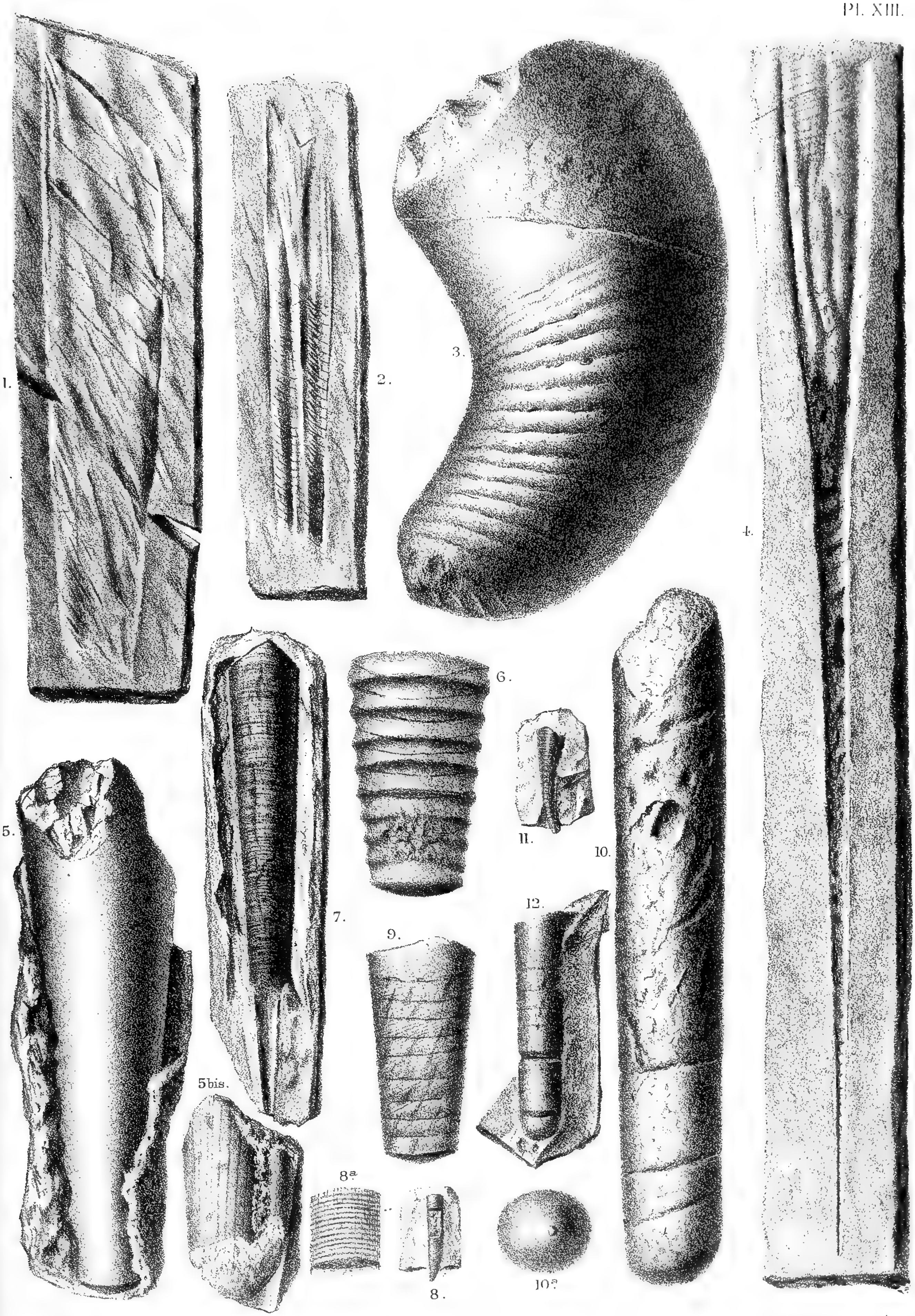
Plate XIII.

Fig.

1. Orthoceras sericeum.—From the Upper Tremadoc, Garth. In the Museum of Owens College, Manchester.
2. *Ibid.*—From the same locality. In the Woodwardian Museum. One of Salter's types.
3. Cyrtoceras fortiusculum.—From the Lower Ludlow, Ledbury. In the Museum of Practical Geology.
4. Orthoceras primævum. — From the Wenlock Shale, Nantglyn. In the Museum of Practical Geology. Possibly Forbes's type.
5. Orthoceras pictum.—From the Bala Shales, Bala. In the Museum of Practical Geology.

5 *bis*. *Ibid.*—From the same locality and collection. Showing the bands of colour.

6. Orthoceras Grayi.—From the Wenlock Limestone, Dudley. In the British Museum.
7. Orthoceras elongatocinctum.—From the Bala Beds, Desertcreat. In the Museum of Practical Geology.
8. *Ibid.* (young.)—From the Bala Limestone, Dent. In the Woodwardian Museum, where it has been called *O. conularia*. *a*, the surface magnified.
9. Orthoceras undulocinctum.—From the Upper Ludlow, Ledbury. In the Museum of Practical Geology.
10. Orthoceras vagans.— From Bala ash, Bala. In the Museum of Practical Geology.
11. *Ibid.*—From the same locality and collection. Showing the apex.
12. *Ibid.*—From the Lower Llandeilo, Shelve. In the Museum of Practical Geology. Showing grooves on the surface.

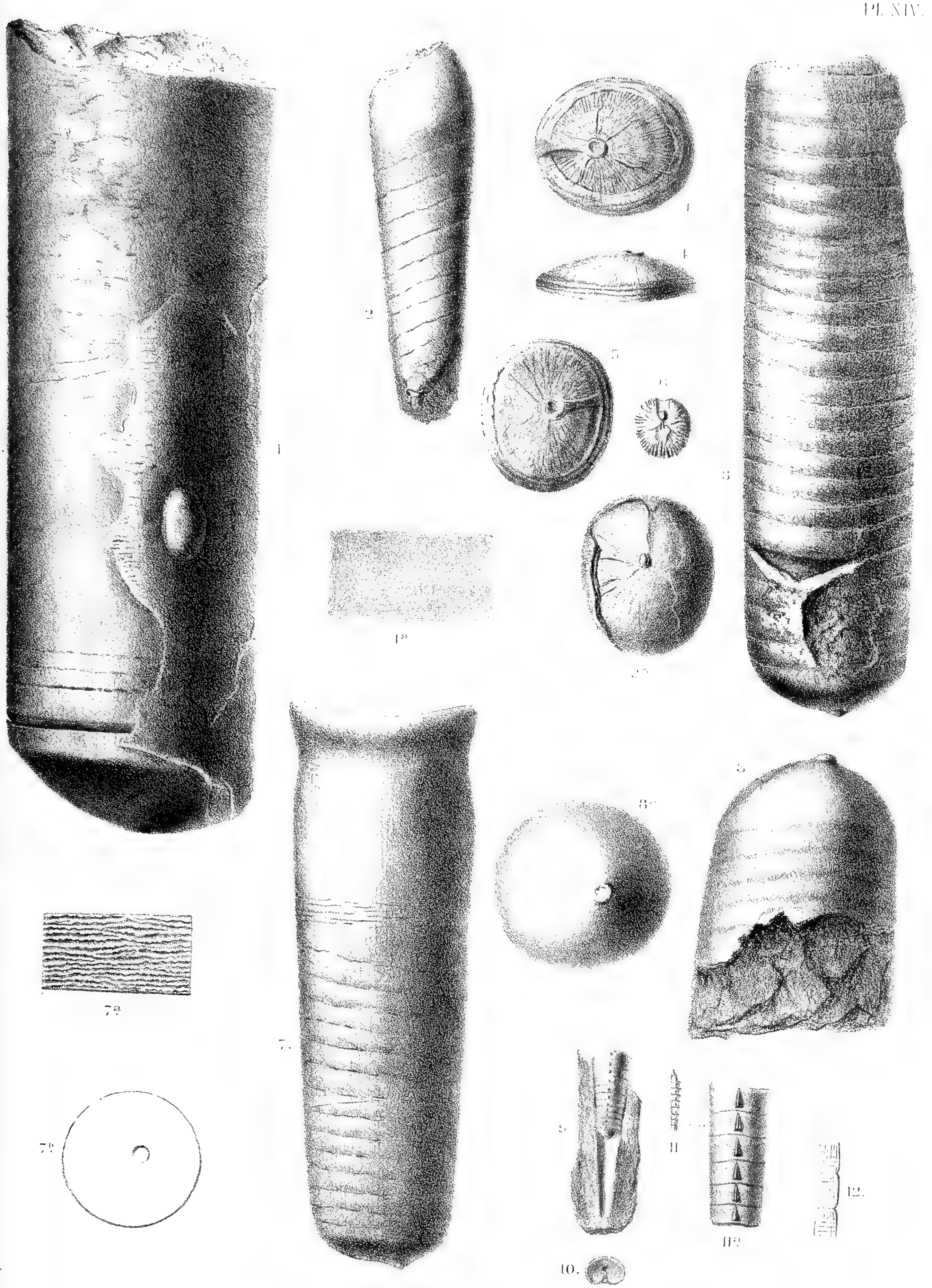


Mintern Bro's imp.

Plate XIV.

Fig.

1. Orthoceras imbricatum.—From the Wenlock Beds, Dudley. In the British Museum. *a*, portion of the surface.
2. Orthoceras druidii.—From the Bala Beds, Cerrig-y-Druidion. In the Museum of Practical Geology.
3. Orthoceras imbricatum.—From the Upper Ludlow, Ludlow. In the collection of G. Cocking, Esq. *a*, the septal surface, showing traces of vascular marks.
4. *Ibid.*—From the Upper Ludlow, Ludlow. In the Museum of Practical Geology. Septal surface, showing an excentric siphuncle, a band to the side, and vascular markings. *a*, side view, showing folds on the surface of the chamber.
5. *Ibid.*—From the same locality. In the collection of G. Cocking, Esq. Showing an oblique band.
6. *Ibid.*—From the same locality. In the Museum of Practical Geology. Showing a depression.
7. Orthoceras fretum.—From the Upper Ludlow, Turner's Hill. In the Museum of Practical Geology. *a*, the surface magnified; *b*, diagram of position of siphuncle and shape of section.
8. Orthoceras truncatum.— From the Woolhope Shales, Littlehope. In the Museum of Practical Geology. *a*, the septal surface.
9. Orthoceras semipartitum. — From the Tilestones, Horeb Chapel. In the Museum of Practical Geology.
10. *Ibid.*—From the same locality and collection. Showing the plate passing to the siphuncle.
11. *Ibid.*—From the same locality and collection. *a*, the same magnified, to show the pseudo-normal line.
12. *Ibid.*—Copy of Phillips's figure for *O. textile.* Mem. Geol. Surv. vol. ii. pt. 1.



A. Gawan, del et lith.

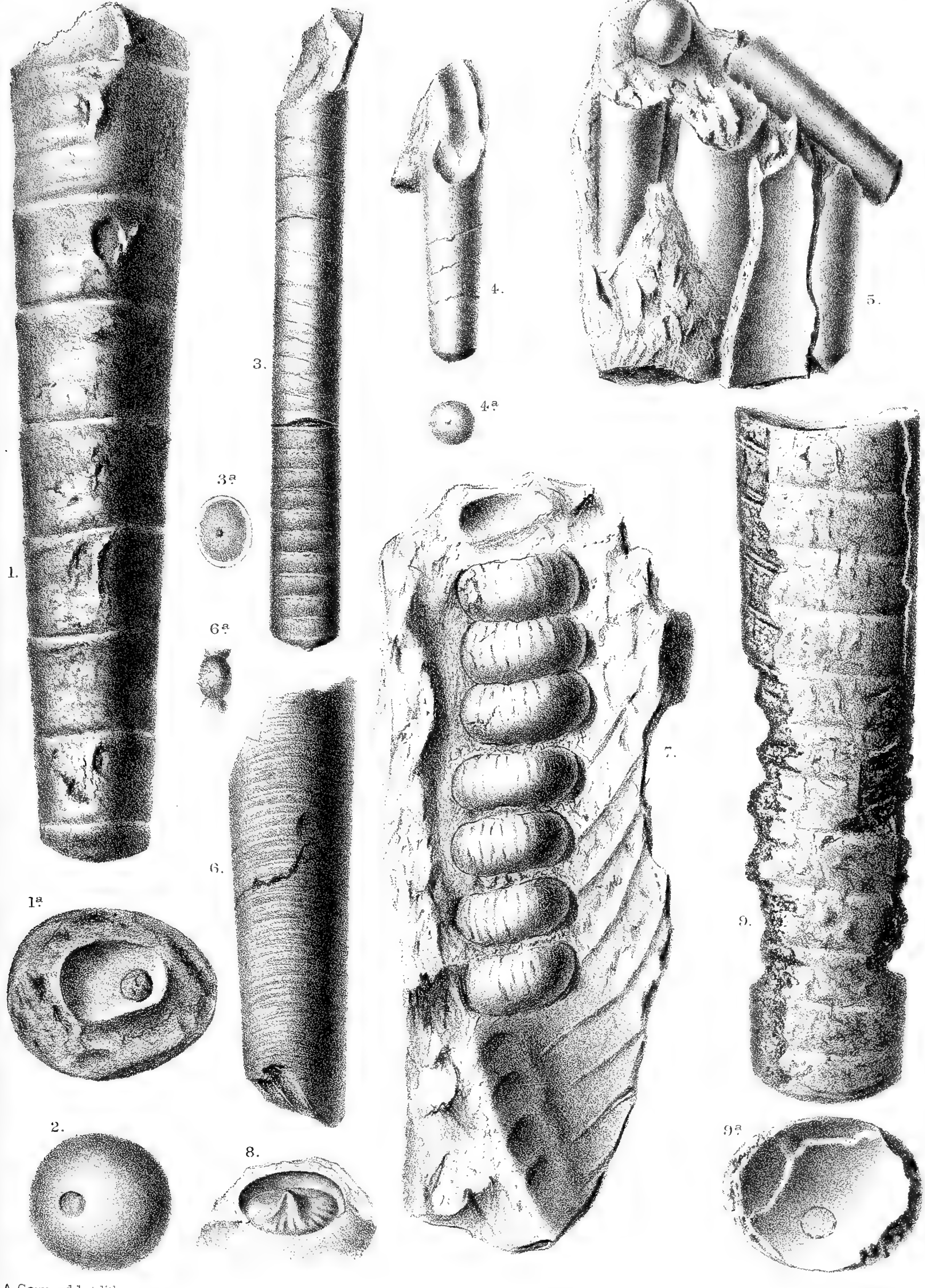
Mintern Bro's imp.

Plate XV.

Fig.

1. Orthoceras distans.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, the upper end, showing the distortion and unsymmetrical siphuncle.
2. *Ibid.*—From the Lower Ludlow, near Aymestry. In the Museum of the Geological Society. End of the septal surface.
3. Orthoceras baculiforme.— From the Upper Ludlow, Brigsteer. In the Woodwardian Museum. *a*, the septal end and the outline at the base of the body-chamber, showing the compression of the former: the bottom part is Salter's type.
4. Orthoceras gregarium.—From the Lower Ludlow, Ludlow. In the Museum of the Geological Society. Part of Sowerby's type. *a*, the septal surface.
5. *Ibid.*—From the Lower Ludlow, Presteign. In the Museum of Practical Geology. Part of a group.
6. Orthoceras mocktreense. — From the Lower Ludlow, Mocktree. In the Museum of the Geological Society. *a*, a bead of the siphuncle.
7. Orthoceras (Actinoceras) cochleatum.—From the Lower Silurian, Guernyfydd. In the British Museum.
8. *Ibid.*—From the Upper Llandovery, Craig-yr-wyddon. In the Museum of Practical Geology. Interior of a siphuncular bead.
9. Orthoceras omissum.—From the Upper Ludlow, Benson Knot. In the Museum of Practical Geology. *a*, the septal surface.

PL. XV.



A. Gawan, del et lith.

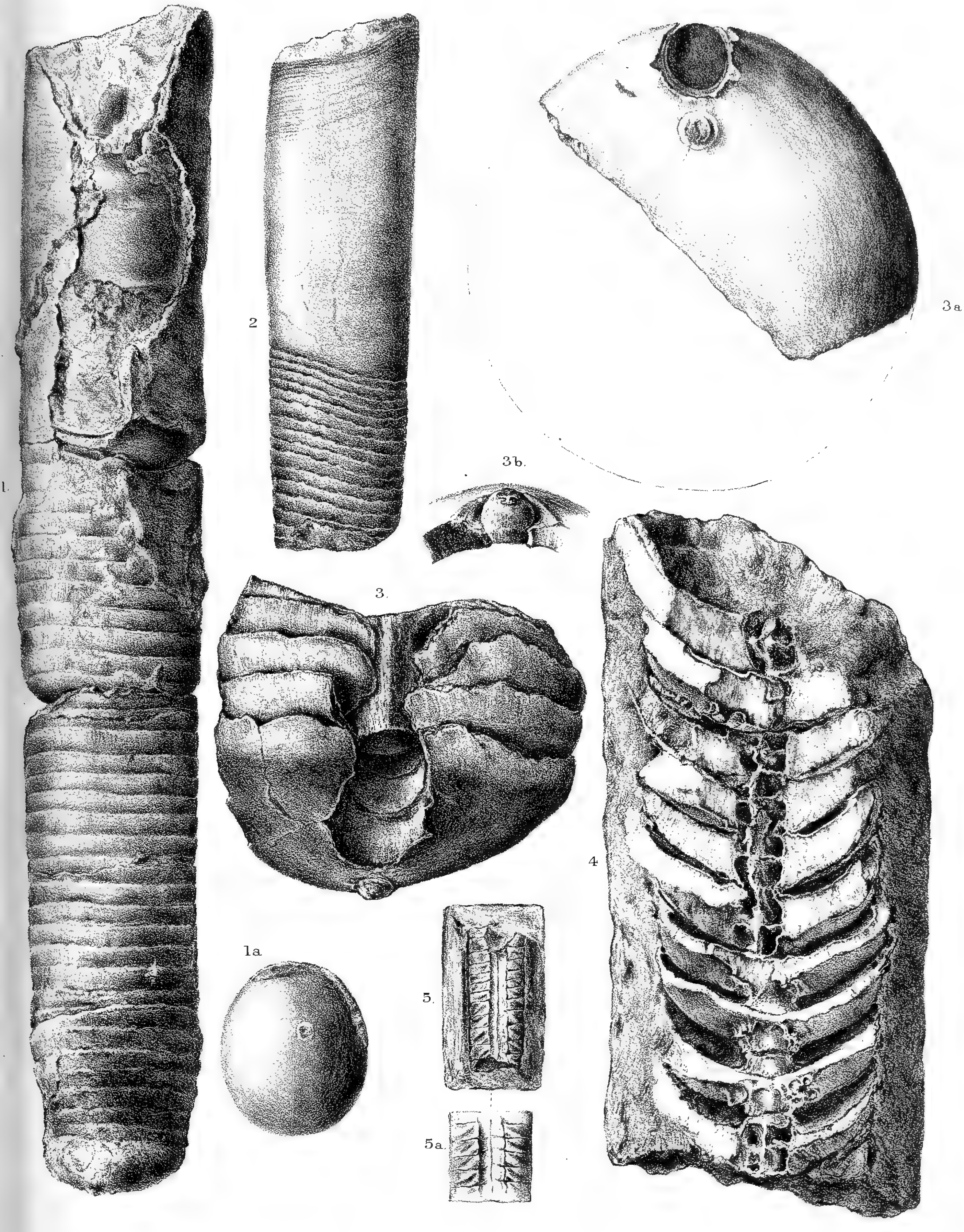
Mintern Bro's imp.

Plate XVI.

Fig.

1. Orthoceras perversum.—From the Upper Ludlow, Ludlow. In the Museum of Owens College, Manchester. *a*, one of the septal surfaces, showing the unsymmetrical siphuncle.
2. *Ibid.*—From the Lower Ludlow, Ludlow. In the Museum of the Geological Society. The specimen figured by Sowerby as *O. imbricatum.*
3. Orthoceras (Tretoceras) bisiphonatum.—From the Lower Llandovery rocks, Llandovery. In the Museum of the Geological Society. *a*, the septal surface, showing the true diameter; *b*, side view of a siphuncular bulb.
4. *Ibid.*—From the Woolhope Beds, Woolhope district. In the collection of Dr. Grindrod. A specimen corresponding to "*Actinoceras baccatum.*"
5. Orthoceras (Conoceras) eoum.— From the Arenig rocks, Shelve. In the Museum of Practical Geology. *a*, a portion enlarged.

Pl. XVI.



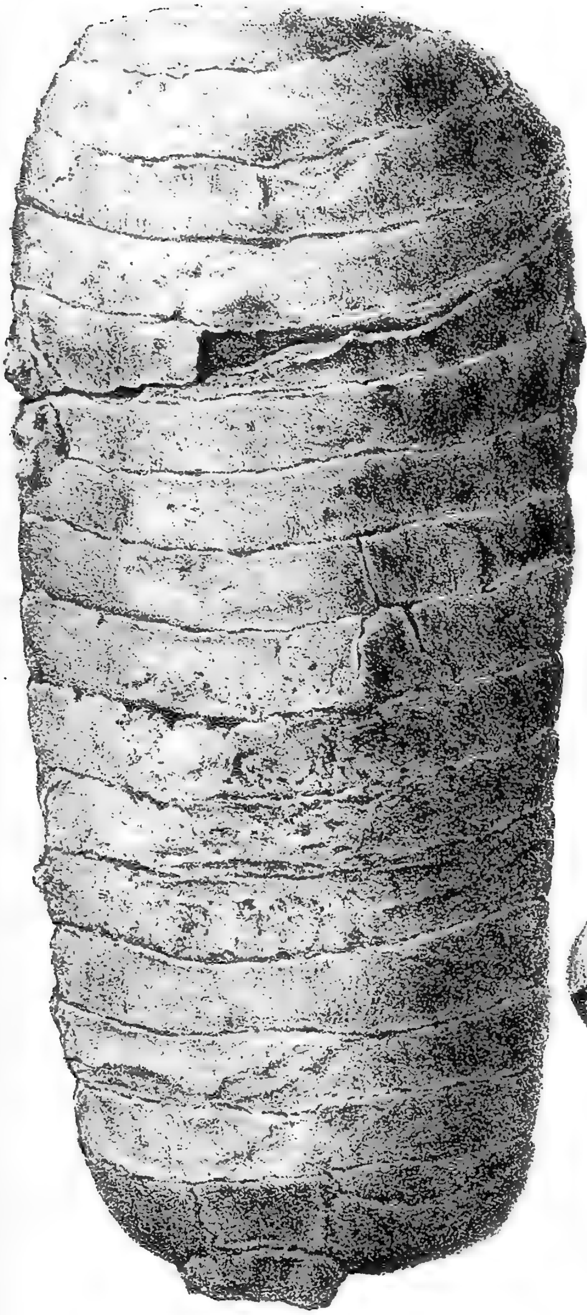
A. S. Foord. del. et lith.

Mintern Bros. imp.

PLATE XVII.

Fig.

1. ORTHOCERAS (ENDOCERAS) BRONGNIARTII.—From the Bala Beds, Desertcreat. In the Museum of Practical Geology. Portlock's figured specimen. *a*, the septal surface.
2. ORTHOCERAS ARANEOSUM.—From the Wenlock Shale, Buildwas. In the Museum of Practical Geology. *a*, part of the surface magnified.
3. ORTHOCERAS (ENDOCERAS) FESTINANS.—From Lower Silurian Beds, Worthin. In the British Museum. *a*, the septal surface.



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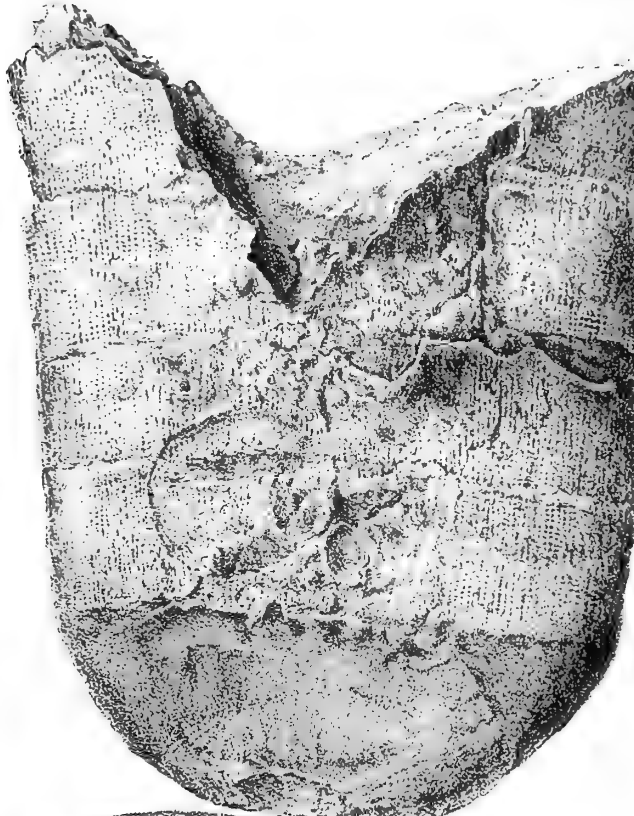

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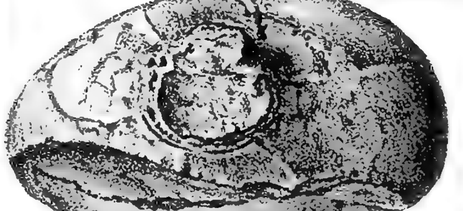

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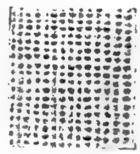

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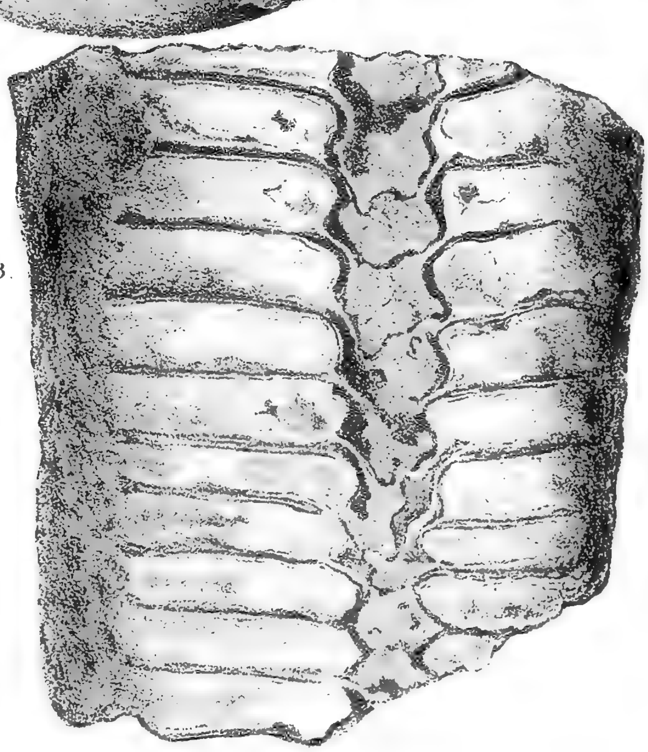

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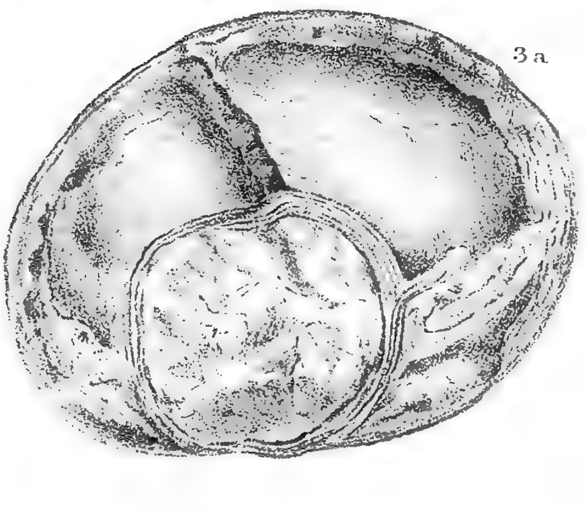


3 a

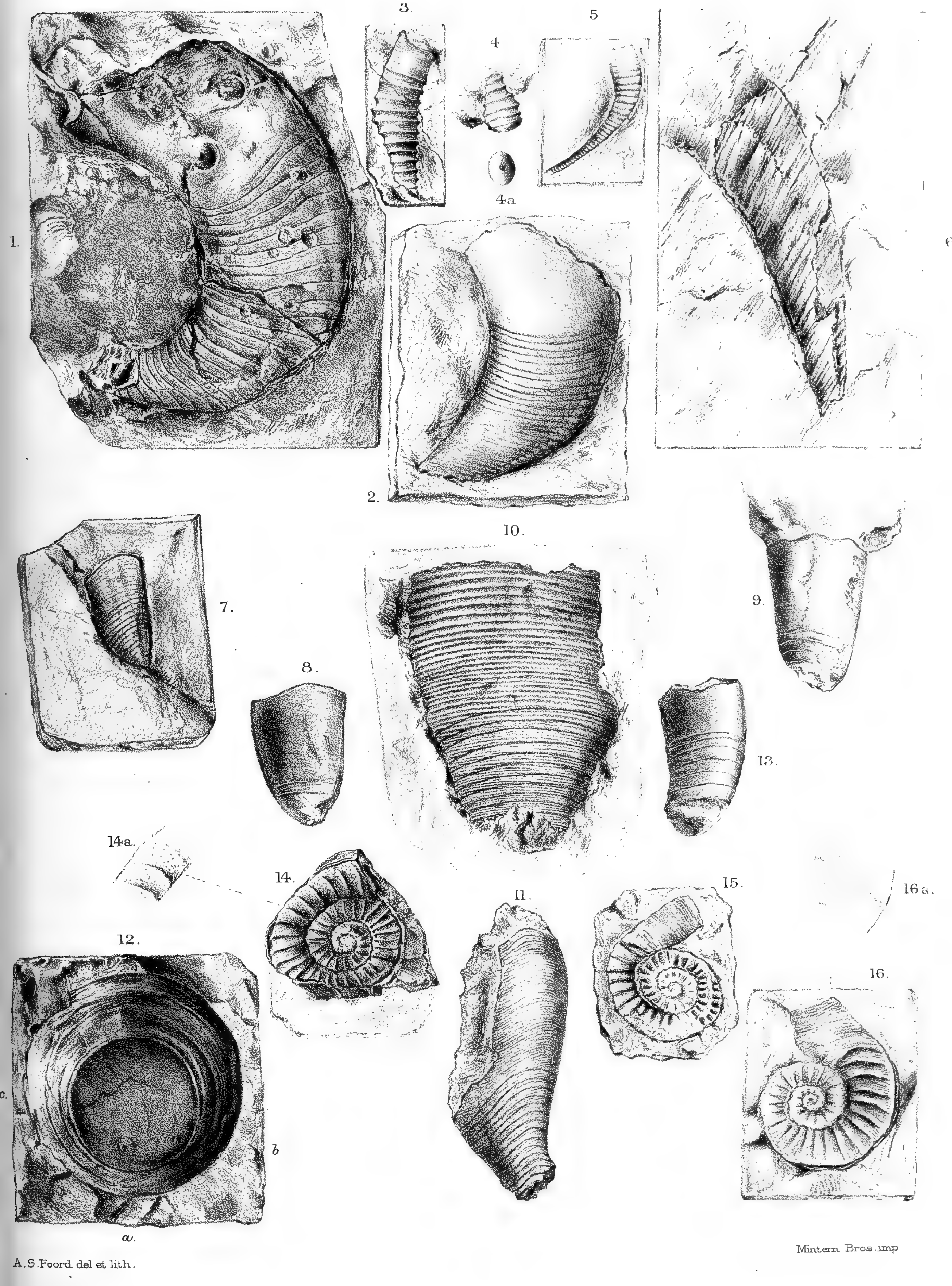
A. S. Foord del. et lith.

Mintern Bros imp.

Plate XVIII.

Fig.

1. Cyrtoceras compressum.—From the Lower Llandovery, Thrave. In the Museum of Practical Geology.
2. *Ibid.*—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
3. Lituites ibex.—From the Upper Ludlow, Ludlow. In the Museum of Practical Geology.
4. *Ibid.*—From the same locality. In the Museum of Owens College, Manchester. *a*, the septal surface.
5. *Ibid.*—From the Lower Ludlow, Leintwardine. In the Museum of Practical Geology. [The apex is too little curved.]
6. Cyrtoceras præcox.—From the Tremadoc Slates, Garth. In the British Museum.
7. *Ibid.*—From the Tremadoc Slates, Llanerch. In the Museum of the University College for Wales, Aberystwith. Salter's type.
8. Orthoceras hungaricum.—From the Bala Shales, Haverfordwest. In the Museum of Practical Geology.
9. Orthoceras xit.—From the Wenlock Shale, Dudley. In the British Museum.
10. Orthoceras Barrandei.—The specimen referred to by Salter as *Gomphoceras liratum.* From the Lower Ludlow, Aymestry. In the Woodwardian Museum. Front view.
11. *Ibid.*—From the Wenlock Shale, Dudley. In the British Museum. Side view, showing the undulating aperture and contortion in youth.
12. *Ibid.* ?—A flattened pair of septal chambers, showing siphuncle, *a*, and two pits, *b*, *c*, with vascular marks. From the Wenlock Limestone, Dudley. In the Woodwardian Museum.
13. Cyrtoceras intermedium ? — From the Wenlock Series, Dudley. In the British Museum.
14. Ophidioceras articulatum.—From the Lower Ludlow, Malvern. In the collection of Dr. Grindrod. *a*, enlarged view of the surface.
15. *Ibid.*—From the Lower Ludlow, Ludlow. In the Ludlow Museum.
16. Ophidioceras geometricum.—From the Lower Ludlow, Ludlow. In the British Museum. *a*, enlarged view of the surface.



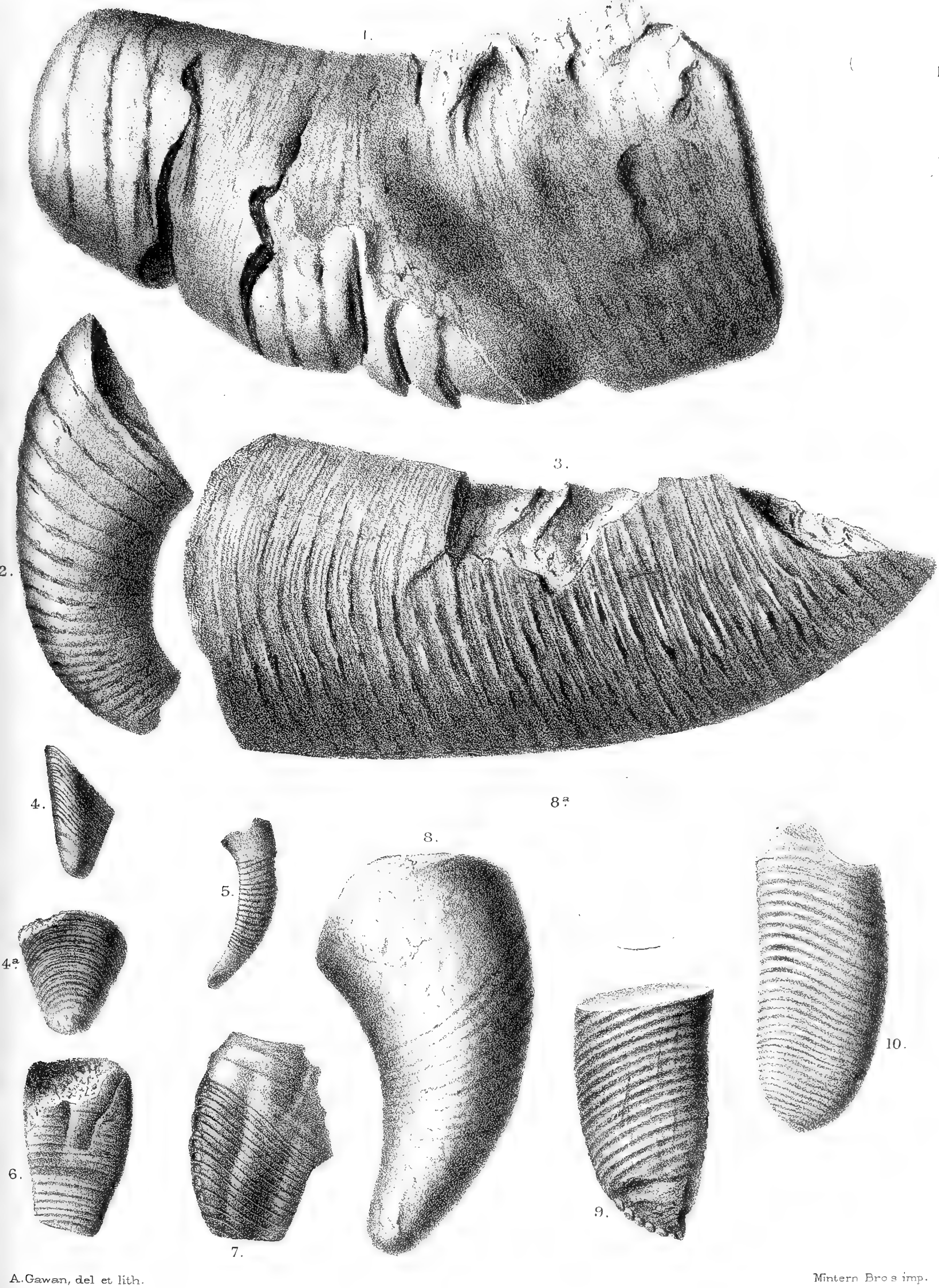
A. S. Foord del et lith.

Mintern Bros. imp

Plate XIX.

Fig.

1. Cyrtoceras sonax.—From the Bala Beds, Rhiwlas. In the Museum of Practical Geology. Salter's type. *a*, outline of the radial section.
2. *Ibid.*—From the same locality and collection. A younger example. Salter's type of C. atramentarium.
3. *Ibid.*—From the Bala Beds, Sholeshook. In the Museum of Practical Geology. The body-chamber and aperture.
4. Orthoceras Barrandei.—From the Wenlock Shale, Ledbury. In the collection of Dr. Grindrod. Side view. 4*a*, front view.
5. Cyrtoceras macrum.—From the Wenlock Limestone, Dudley. In the British Museum.
6. Cyrtoceras isca.—From the Wenlock Limestone, Garcoed, Usk. In the Museum of Practical Geology. Showing the surface.
7. *Ibid.*—From the same locality and collection.
8. Cyrtoceras corniculum.—From the Wenlock Limestone, Dudley. In the Woodwardian Museum. *a*, outline of the radial section.
9. Cyrtoceras contrarium.—From the Wenlock Shale, Usk. In the Museum of the Cardiff Naturalists' Society.
10. *Ibid.*—From the same locality. In the Museum of Practical Geology.



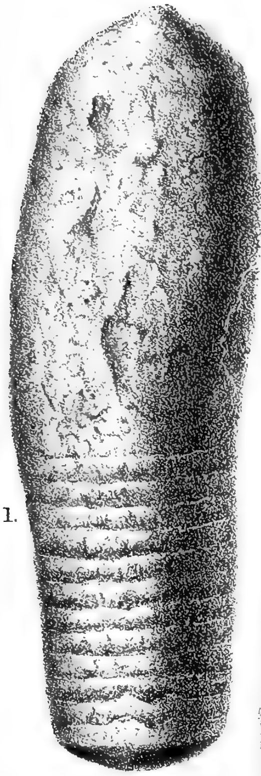
A.Gawan, del et lith. Mintern Bros imp.

Plate XX.

Fig.

1. Cyrtoceras approximatum.—From Wenlock Beds (?), Dudley. In the British Museum. *a*, the septal surface; siphuncle undiscoverable.
2. Trochoceras ? cinereum.—From the Bala Beds, Desertcreat. In the Museum of Practical Geology.
3. Cyrtoceras macrum.—From the Bala Beds, Rhiwlas. In the Museum of Practical Geology.
4. Cyrtoceras alternatum.—From the Bala Beds, Bala. In the Museum of Practical Geology.
5. Cyrtoceras inæquiseptum.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology. The type of Portlock's *Phragmoceras Brateri*. *a*, the outline of the section.
6. Cyrtoceras intermedium.—From the Lower Ludlow, Ludlow. In the Museum of the Geological Society. One of the specimens figured by Sowerby as *Phragmoceras arcuatum*. *a*, outline of present section.
7. Cyrtoceras subarcuatum.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology. *a*, outline of the section.
8. Cyrtoceras inæquiseptum.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology. Portlock's type.

Pl. XX.



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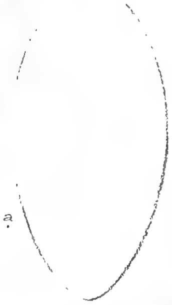

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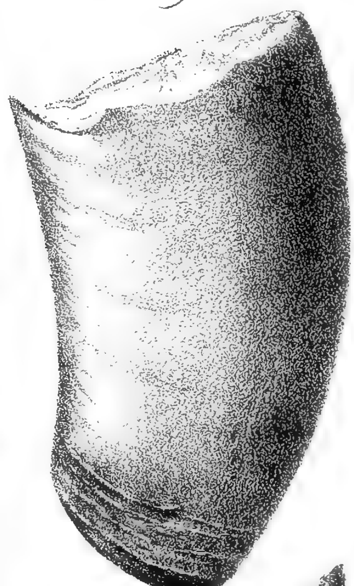

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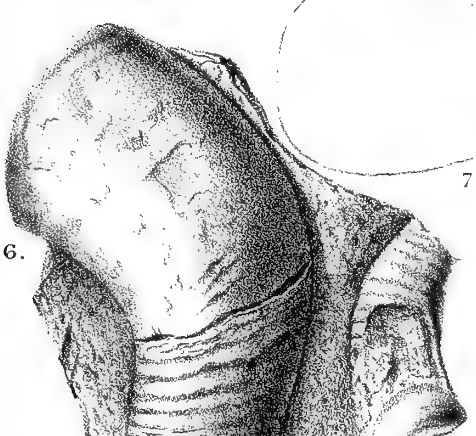

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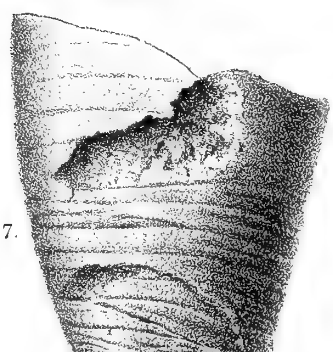

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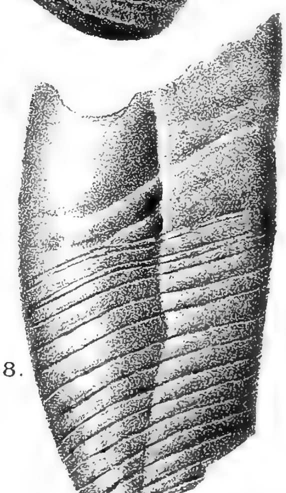


8.

A. Gawan, del et lith.

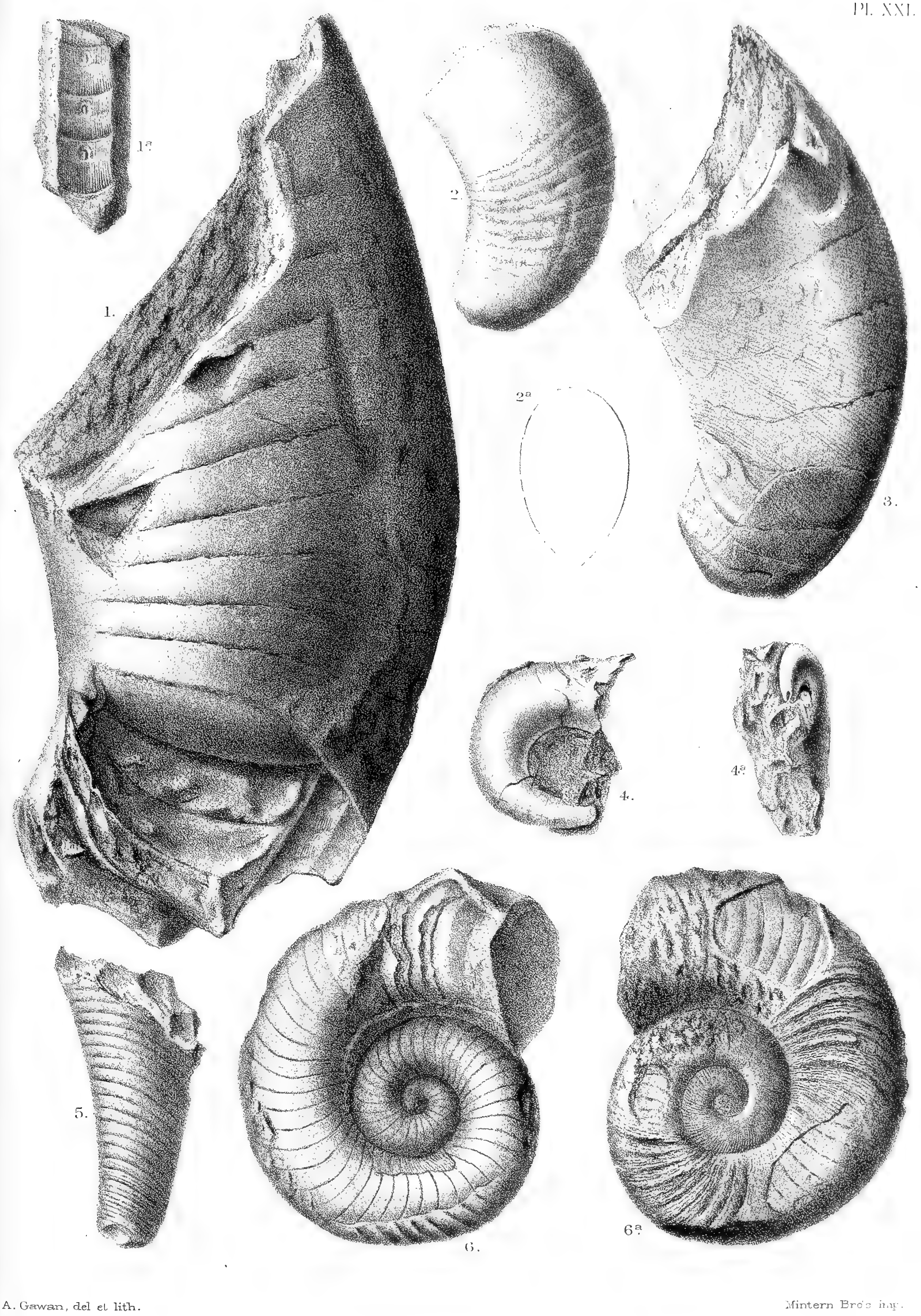
Mintern Bro's imp.

Plate XXI.

Fig.

1. Cyrtoceras llandoveri.—From the Upper Llandovery rocks, Craig-yr-Wyddon. In the Woodwardian Museum. *a*, fragment of the siphuncle cast, showing the subdivision and lineation of the concave elements and the tubercle on the upper half.
2. Cyrtoceras intermedium.—From the Lower Ludlow, Leintwardine. In the Woodwardian Museum. M'Coy's type. *a*, the outline section.
3. Cyrtoceras uranus.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
4. Cyrtoceras scoticum.—From the Bala Beds, Broughton. In the Museum of the Geological Survey, Edinburgh. *a*, front view of the same, showing the apex and cicatrix.
5. Cyrtoceras reversum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
6. Trochoceras cornu-arietis.—From the Bala Beds, Sholeshook. In the Museum of Practical Geology. *a*, the reverse side.

Pl. XXI.



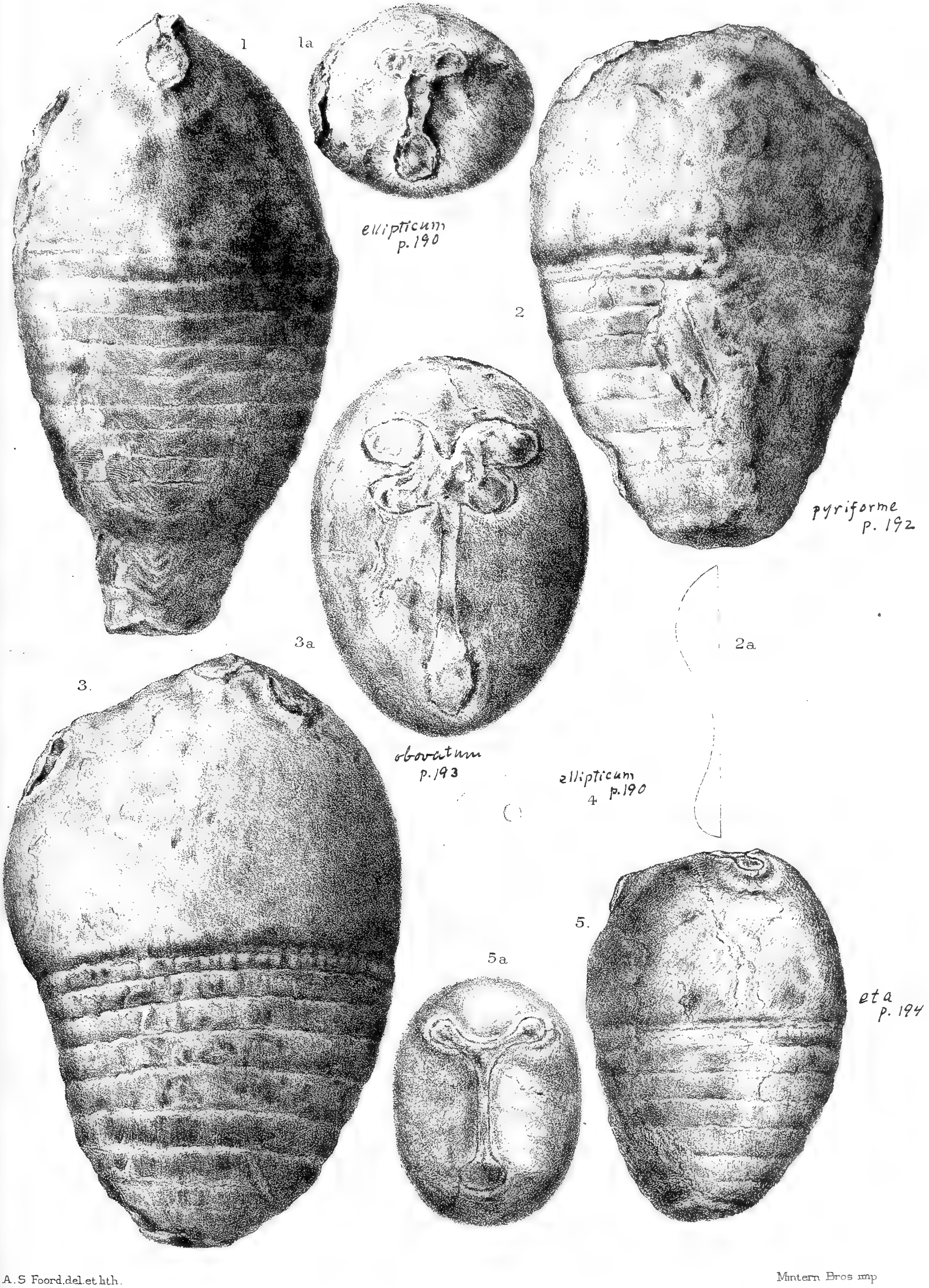
A. Gawan, del et lith.

Mintern Bro's imp.

Plate XXII.

Fig.

1. Gomphoceras ellipticum.—From the Lower Ludlow, Leintwardine. Sowerby's type. In the Museum of the Geological Society. Seen from the ventral side. *a*, reduced view of the front, showing the transverse shape and the aperture.
2. Gomphoceras pyriforme.—From the Lower Ludlow, Leintwardine. In the Museum of Practical Geology. *a*, the outline of one-half the aperture.
3. Gomphoceras obovatum.—From the Lower Ludlow, Ludlow. In the Ludlow Museum. *a*, front view, showing the aperture.
4. Gomphoceras ellipticum.—Outline of section, with position of siphuncle (position reversed from fig. 1). From an example from the Lower Ludlow of Herefordshire. In the British Museum.
5. Gomphoceras eta.—From the Lower Ludlow, Mocktree. In the British Museum. *a*, front view, showing the aperture.



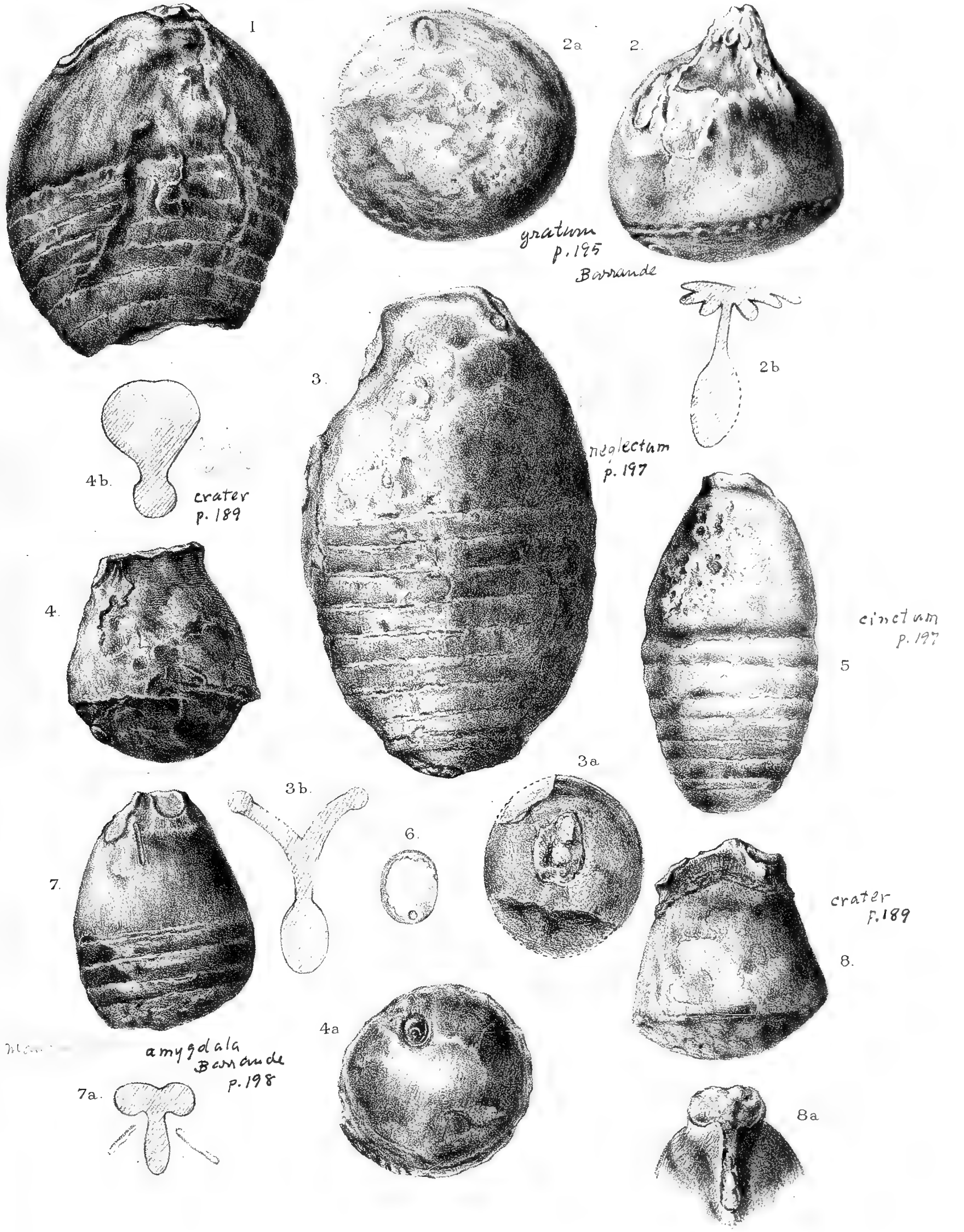
A. S Foord del. et lith.

Mintern Bros imp.

Plate XXIII.

Fig.

1. Gomphoceras gratum.—From the Lower Ludlow, Garcoed, Usk. In the Museum of the Cardiff Naturalists' Society. A compressed specimen.
2. *Ibid.*—From the Lower Ludlow, Leintwardine. In the Museum of Practical Geology. A drawn-out specimen. *a*, the septal surface; *b*, diagram of the aperture.
3. Gomphoceras neglectum.—From the Lower Ludlow, Aymestry. In the Woodwardian Museum. *a*, the septal surface; *b*, diagram of the aperture—(rather theoretical.)
4. Gomphoceras crater.—From the Wenlock Limestone, Malvern. In the Museum of Practical Geology. *a*, the septal surface; *b*, outline of the termination of the shell (? the aperture).
5. Gomphoceras cinctum.—From the Lower Ludlow, Ludlow. In the British Museum.
6. *Ibid.*—From the Wenlock Limestone, Dudley. In the British Museum. Septal surface.
7. Gomphoceras amygdala ?—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, diagram of the front view, showing the depressions on either side of the aperture.
8. Gomphoceras crater.—From the Wenlock Limestone, Malvern. In the Museum of Practical Geology. *a*, front view, showing the aperture.



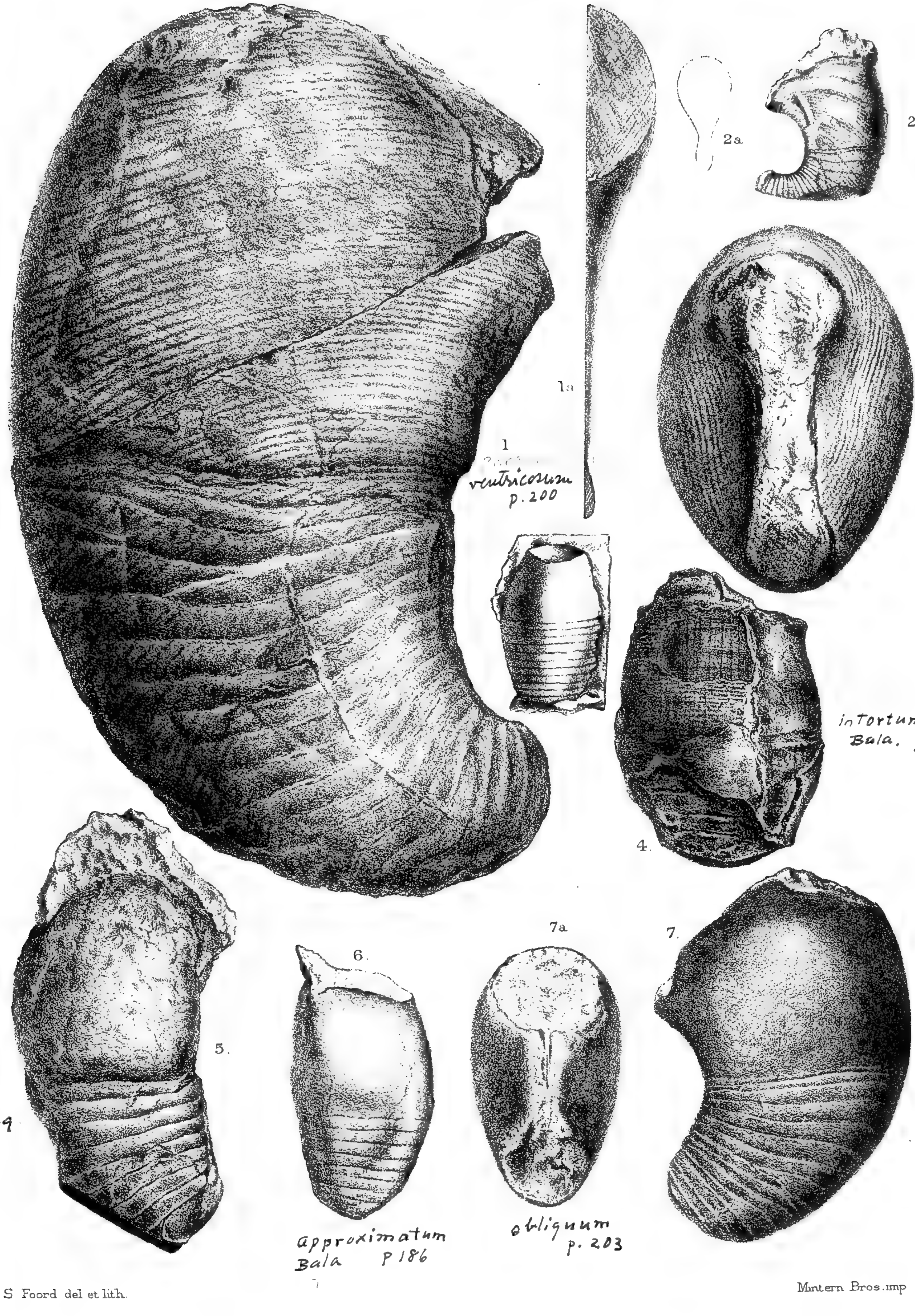
A. S Foord. del et lith.

Mintern Bros. imp.

Plate XXIV.

Fig.

1. Phragmoceras ventricosum.—From the Lower Ludlow, Aymestry. In the Museum of the Geological Society. Sowerby's type. *a*, diagram of half the aperture in the adult.
2. *Ibid.*—From the May Hill Sandstone. In the Woodwardian Museum. *a*, outline of the aperture.
3. *Ibid.*—From the Wenlock Limestone, Dudley. In the British Museum. Front view.
4. Poterioceras (?) intortum.—From the Bala Series, Piedmont, Ayrshire. In the Museum of Practical Geology.
5. Phragmoceras prius.—From the Bala Beds of Rhiwlas, Bala. In the Museum of Practical Geology.
6. Poterioceras (?) approximatum.—From Bala Beds, Twll Ddu. In the Museum of Practical Geology.
7. Phragmoceras obliquum.—From the Wenlock Limestone, Dudley. In the Woodwardian Museum. *a*, front view, showing the aperture.



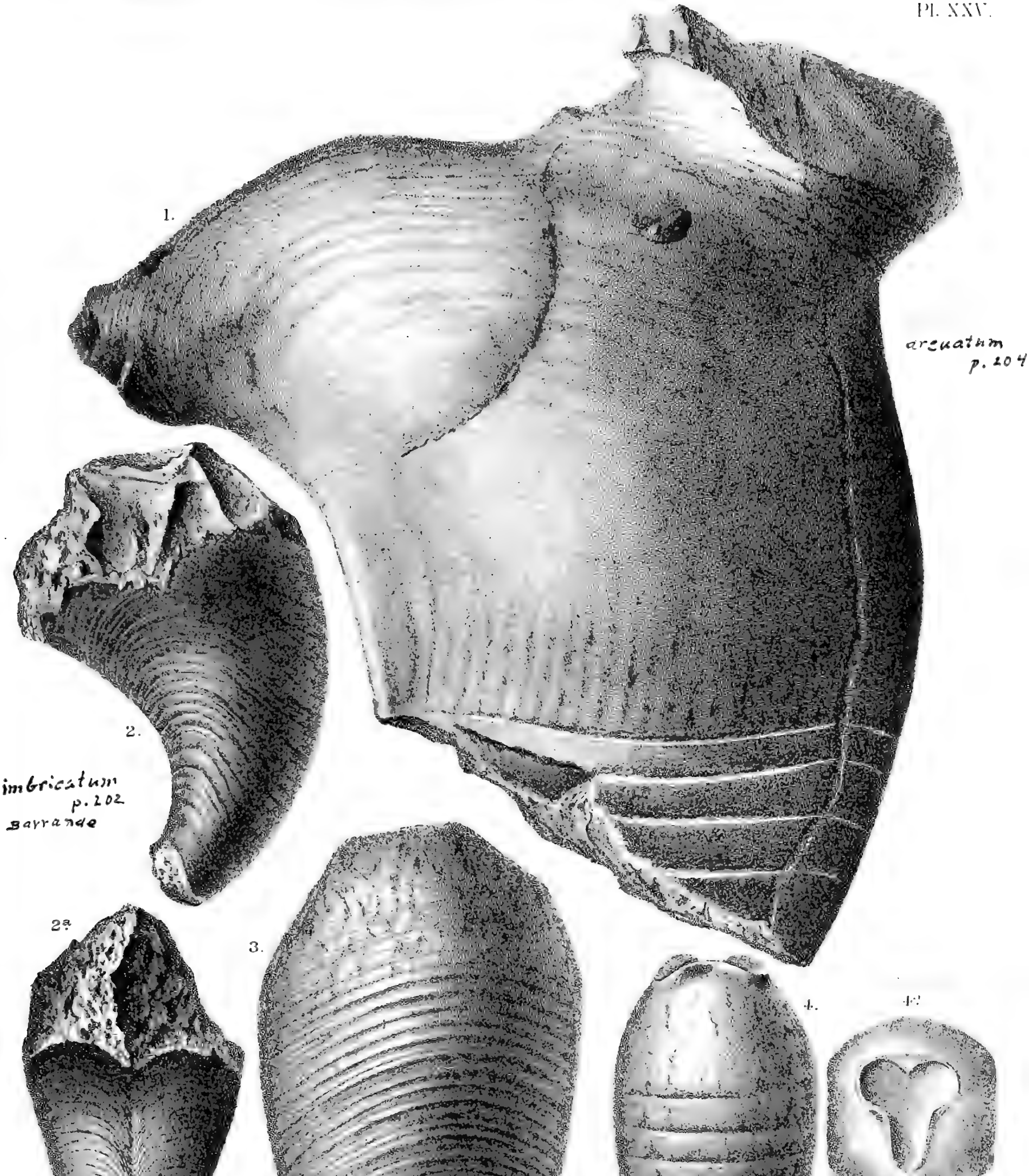
A. S Foord del et lith.

Mintern Bros. imp

Plate XXV.

Fig.

1. Phragmoceras arcuatum.—From the Lower Ludlow of Ledbury. In the collection of Dr. Grindrod. A flattened cast.
2. Phragmoceras imbricatum.—From the Wenlock Limestone of Ledbury. In the collection of Dr. Grindrod. *a*, the same seen on the ventral side.
3. Phragmoceras subexternum.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod.
4. Gomphoceras amygdala.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, the aperture somewhat restored; *b*, the septal surface.



A. Gawan, del et lith.

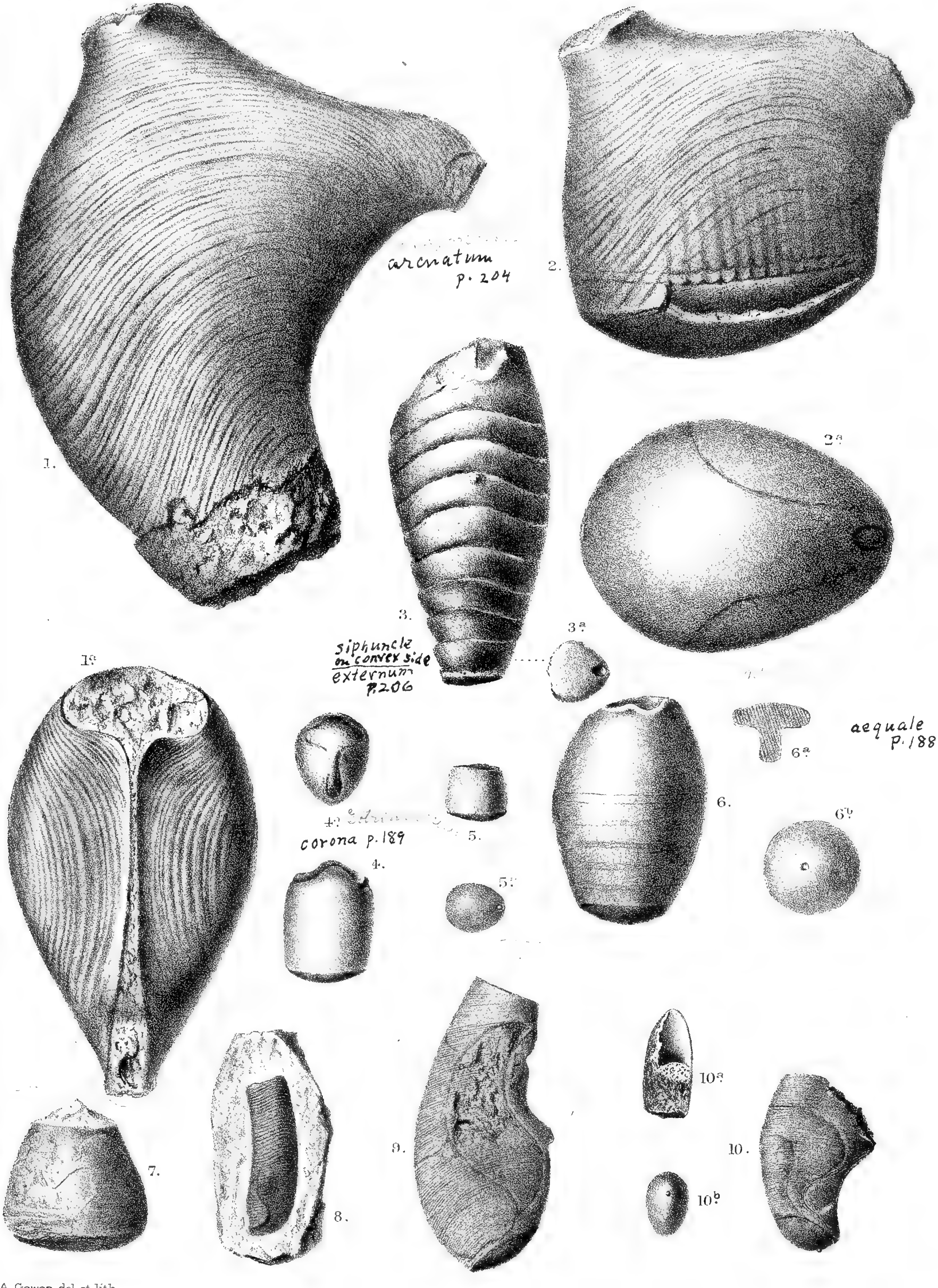
Mintern Bro's imp.

Plate XXVI.

Fig.

1. Phragmoceras arcuatum.—From the Wenlock Limestone, Dudley. In the Museum of Practical Geology. *a*, front view, showing the aperture.
2. *Ibid.*—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. Part of the specimen. *a*, the septal surface.
3. Phragmoceras externum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, the septal surface.
4. Gomphoceras corona.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod. *a*, front view, showing the aperture.
5. *Ibid.*—From the same locality and collection. A small example, which is supposed to have not yet formed its contracted aperture. *a*, the septal surface.
6. Gomphoceras æquale.—From the Wenlock Limestone, Dudley. In the Woodwardian Museum. *a*, outline of the aperture; *b*, the septal surface.
7. Gomphoceras corona.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod. Seen from the dorsal side.
8. Ascoceras vermiforme.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
9. Ascoceras Barrandei.—From the Upper Ludlow, Stansbatch. In the Museum of Practical Geology. Salter's type.
10. Ascoceras bohemicum.—From the Upper Ludlow, Whitecliff. In the Museum of Practical Geology.[1] *a*, part of the uppermost sigmoid septal surface; *b*, the ordinary septal surface.

[1] The apparently most convex side corresponds to the right-hand side of fig. 9.



A. Gawan, del et lith.

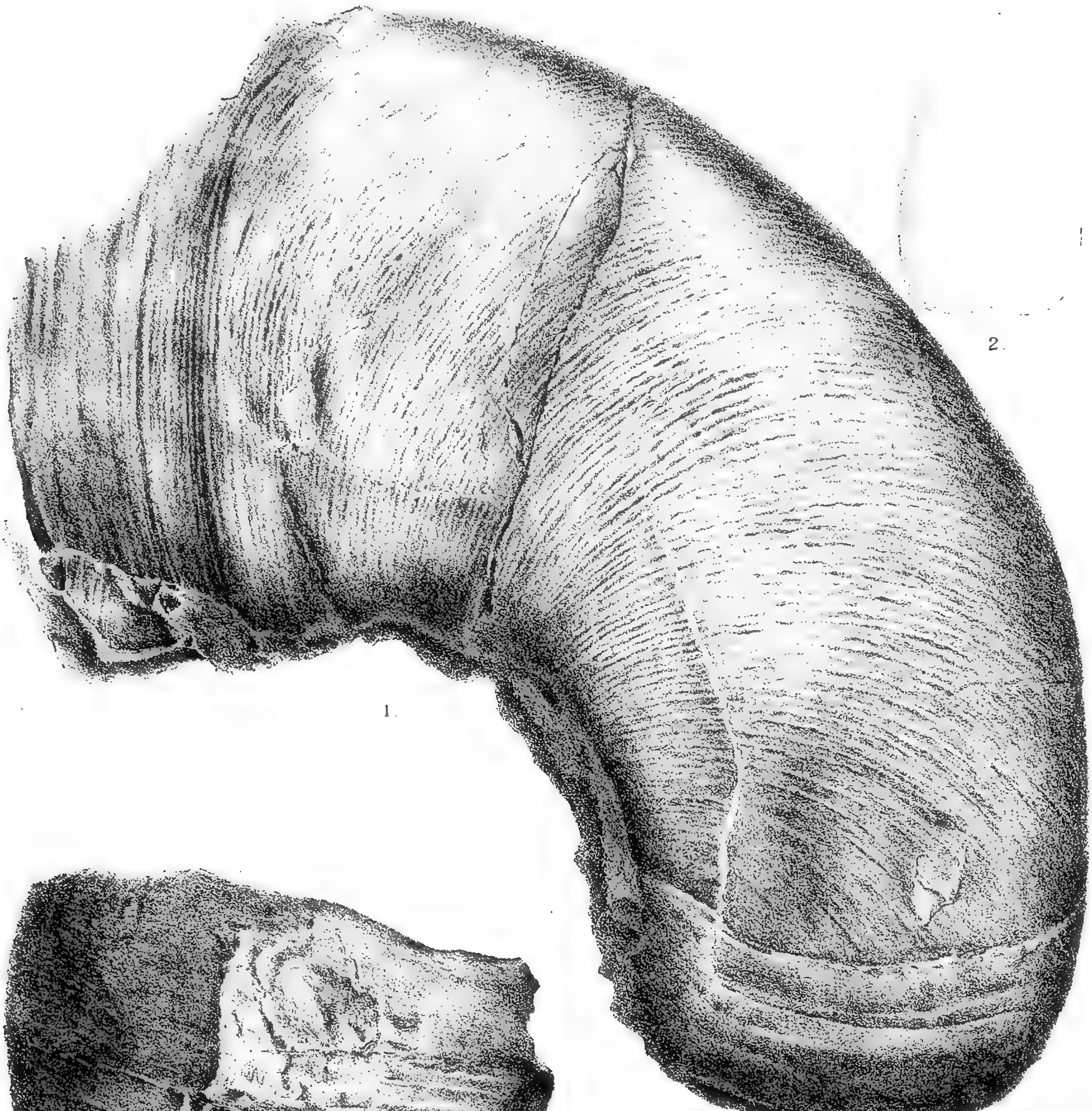
Mintern Bro's imp.

Plate XXVII.

Fig.

1. Nautilus bohemicus.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
2. *Ibid.*—Outline of the septal surface of a specimen from the same locality and collection.
3. Cyrtoceras magnum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, outline of the radial section.
4. Goniatites (?) nautilaceum.—From the Lower Ludlow, Charlton Brook. In the Museum of the Geological Society. Sowerby's type specimen.

Pl. XXVII



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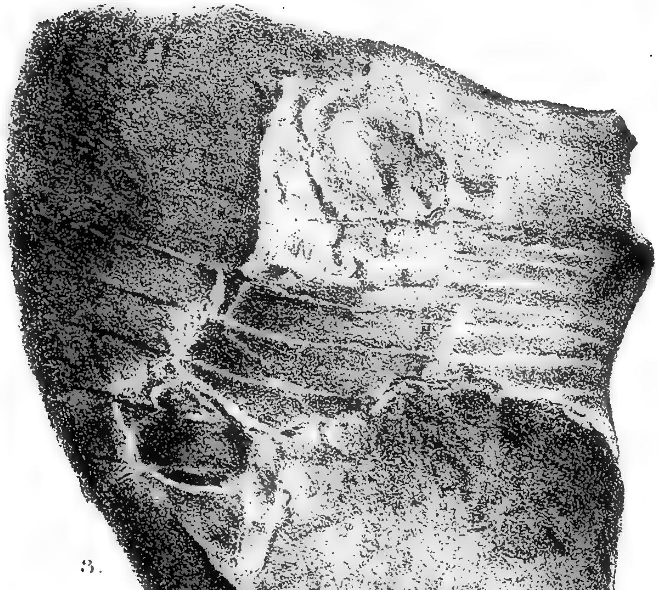

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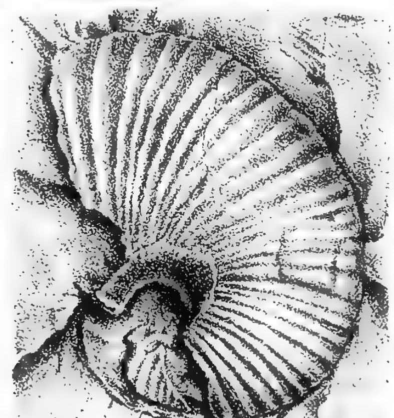


4.

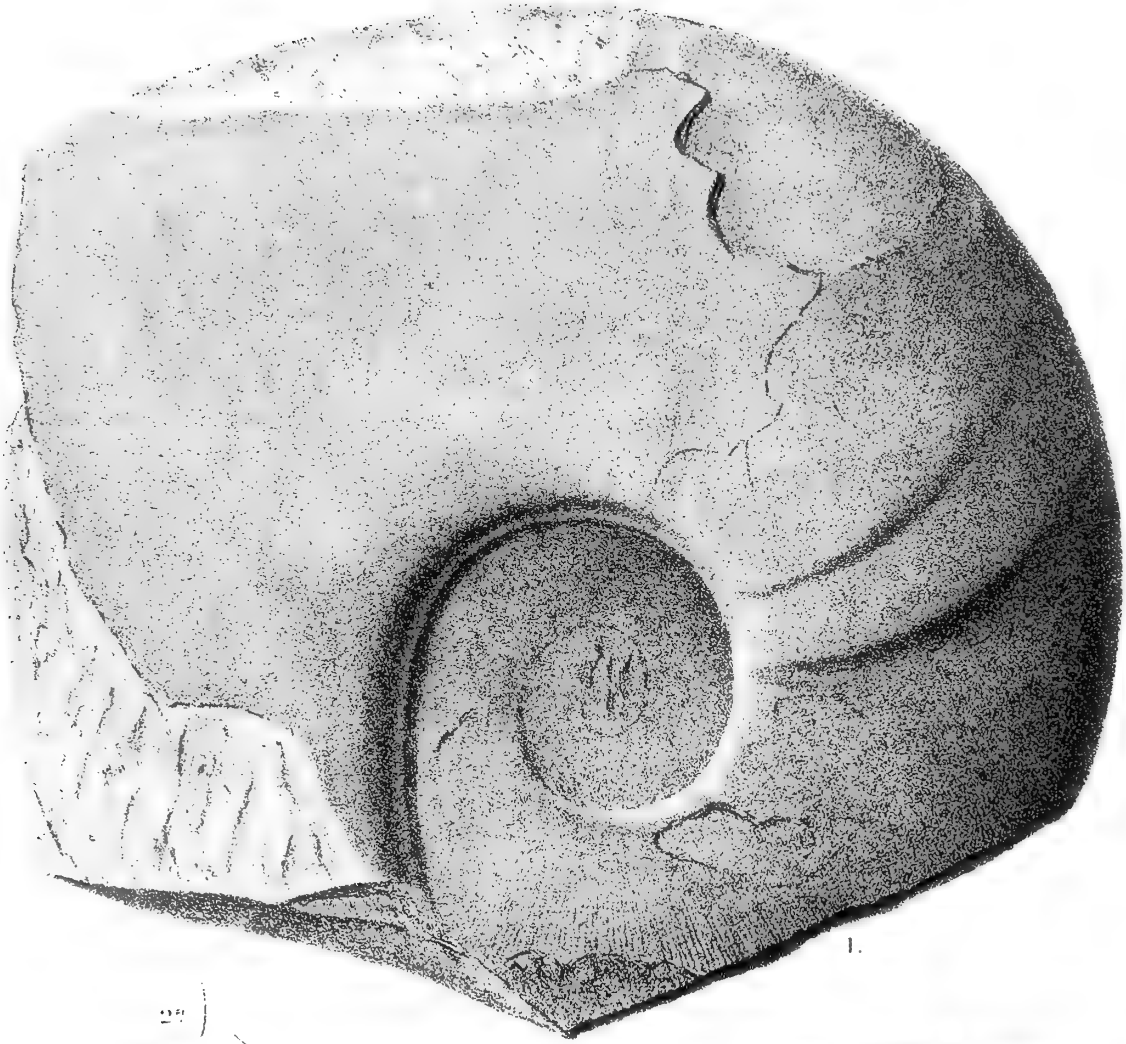
A. S. Foord del et lith.

Mintern Bros. imp.

Plate XXVIII.

Fig.

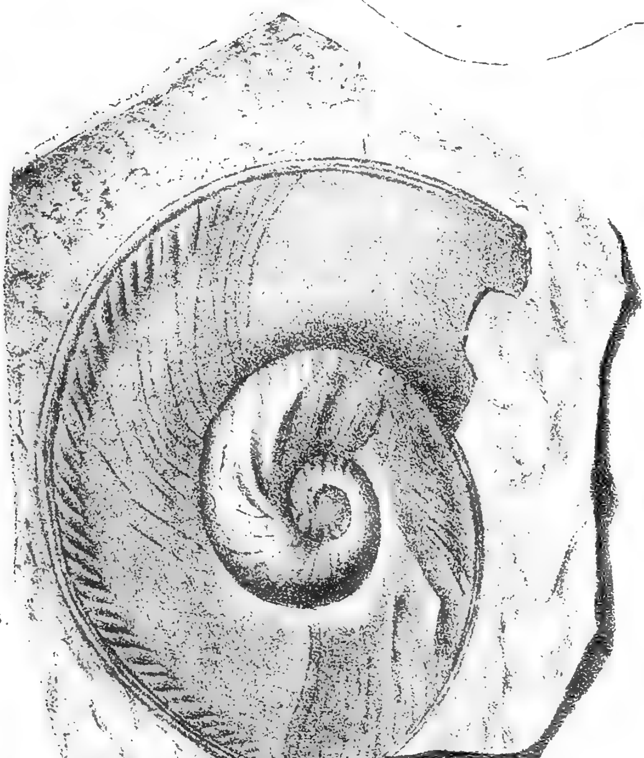
1. Nautilus Holtianus.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
2. Nautilus (Trocholites) anguiformis.—From the Bala Limestone, Llangollen. In the Woodwardian Museum. *a,* outline of the suture.
3. Trochoceras speciosum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
4. Nautilus (Trocholites) scoticus.—From the Upper Llandovery, Bogmine, Shelve. In the Museum of Practical Geology. A young specimen.
5. Trochoceras cornu-arietis.—From the Bala Shales, Desertcreat. In the Museum of Practical Geology. Portlock's figured specimen.



1.

2a

2.



3.

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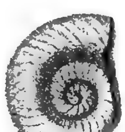

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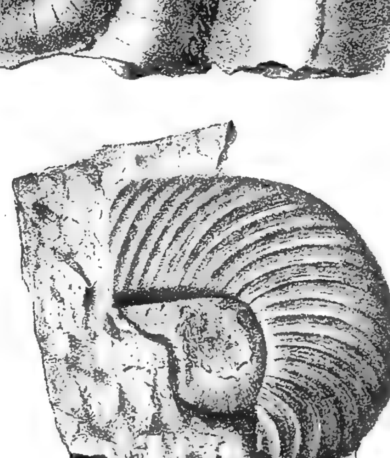


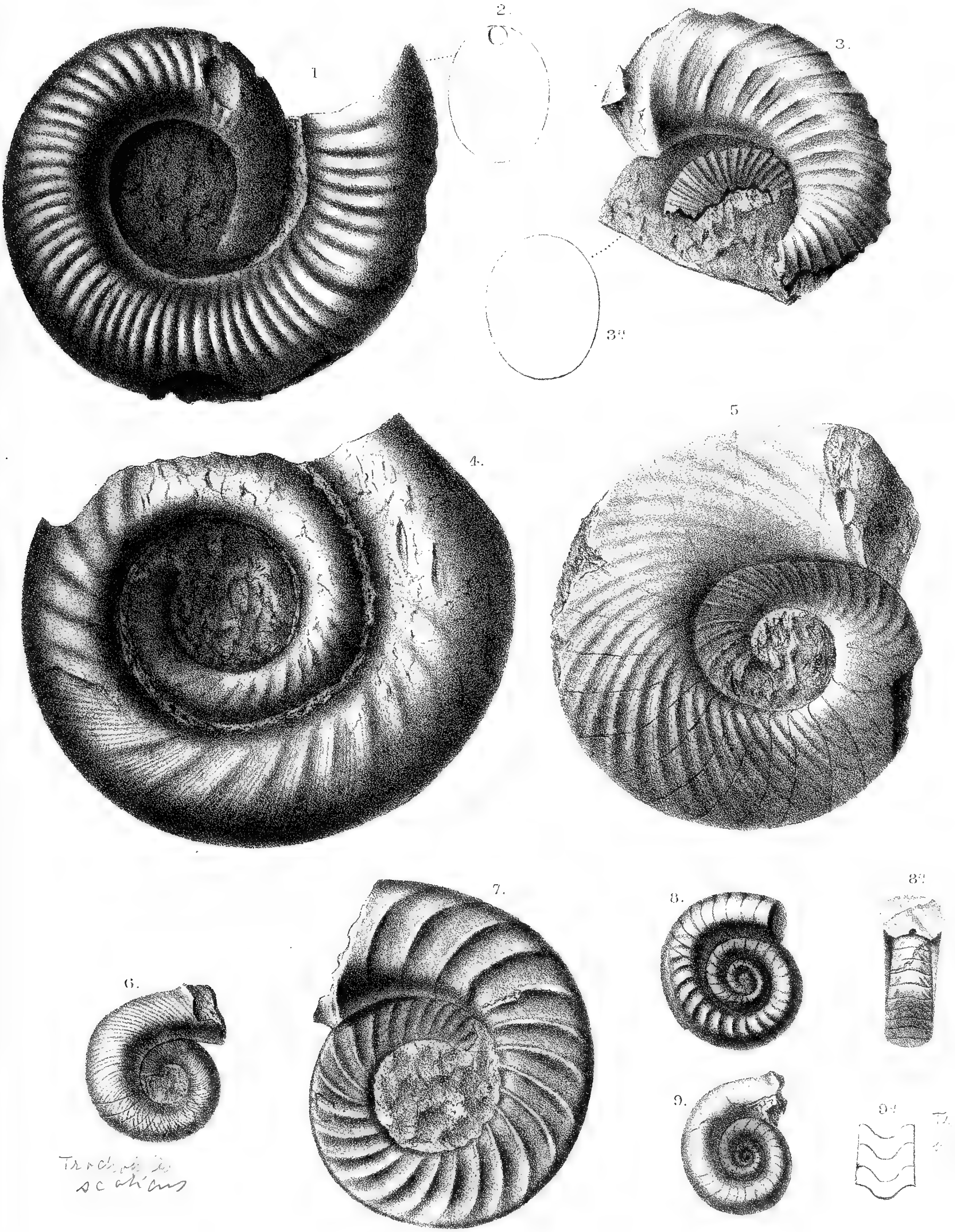
A. Gawan, del et lith.

Mintern Bro's imp.

Plate XXIX.

Fig.

1. Trochoceras speciosum.—From the Wenlock Limestone, Ledbury. In the collection of Dr. Grindrod.
2. *Ibid.*—From the same locality and collection. Outline of the radial section.
3. Trochoceras asperum.—From the Wenlock Shale, Eastnor Park. In the collection of Dr. Grindrod. *a*, diagram of the radial section.
4. Trochoceras gyrans.—From the Wenlock Limestone, Eastnor Park. In the collection of Dr. Grindrod.
5. Trochoceras striatum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
6. Nautilus (Trocholites) scoticus.—From the Bala Series, Glenwhapple. In the Museum of Practical Geology.
7. Trochoceras regulare.—From the Wenlock Limestone, Dudley. In the British Museum.
8. Nautilus (Trocholites) planorbiformis.—From the Lower Llandovery, Golengoed. In the Museum of Practical Geology. *a*, front view of the same. Salter's figured specimen.
9. *Ibid.*—From the Bala Limestone, Chair of Kildare. In the Museum of Practical Geology. *a*, outline of front to show curve of the sutures? Salter's type of *Lituites hibernicus*.



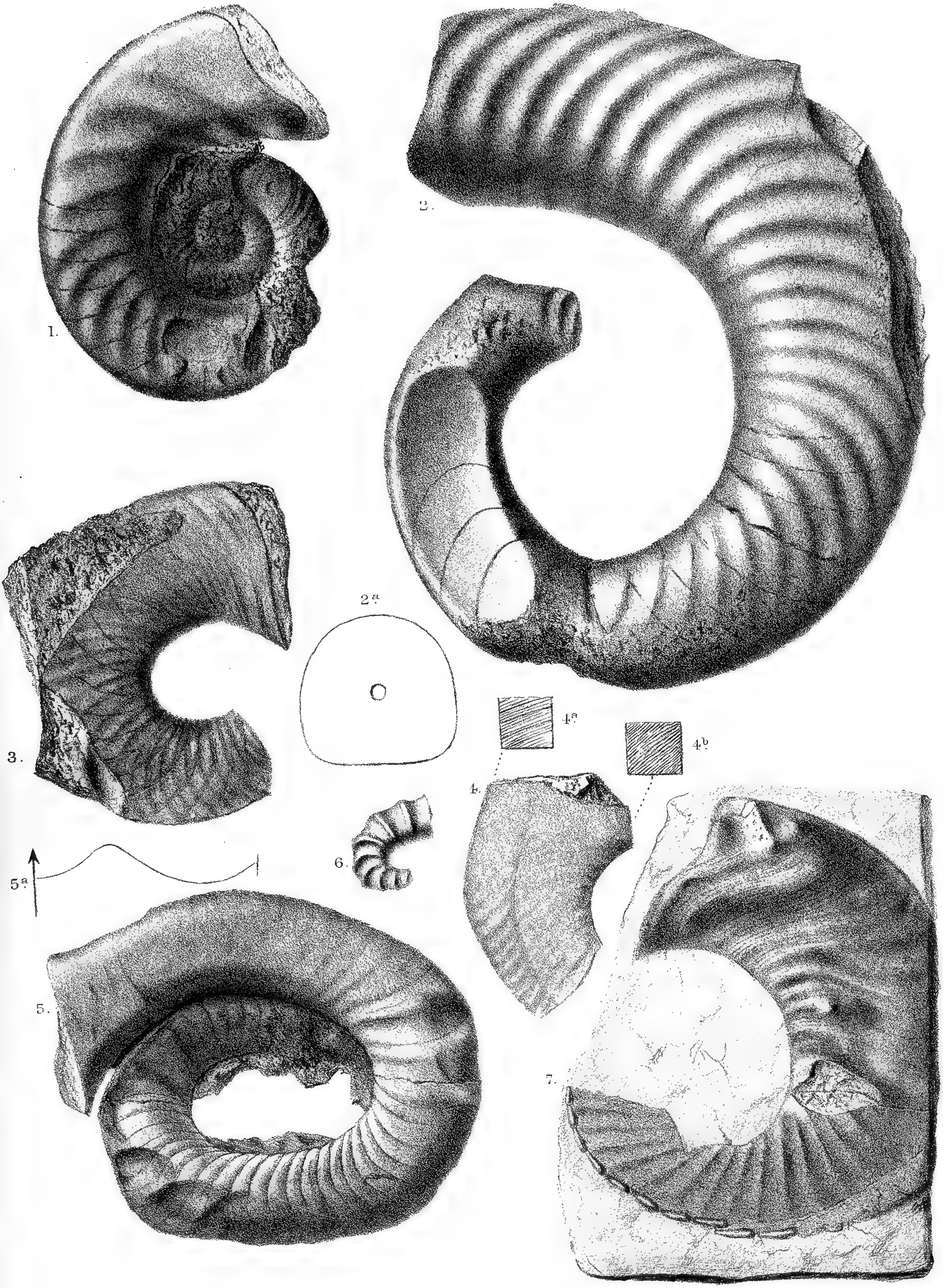
A. Gawan, del et lith.

Mintern Bro's imp.

Plate XXX.

Fig.

1. Nautilus quadrans.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.
2. Trochoceras rapax.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a*, outline of the radial section.
3. Trochoceras striatum.—From the Wenlock Shale, Garcoed, Usk. In the Museum of Practical Geology.
4. *Ibid.*—From the same locality and collection. *a*, magnified view of the surface near the convex side, showing ornaments. *b*, ditto near the concave side, showing epidermids.
5. Trochoceras undosum.—From the Lower Llandovery, Llandovery. In the Museum of Practical Geology. *a*, outline of the sutures. Sowerby's type.
6. *Ibid.*—From the same locality. In the Museum of Practical Geology. A young example.
7. Cyrtoceras (?) equisetum.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod.



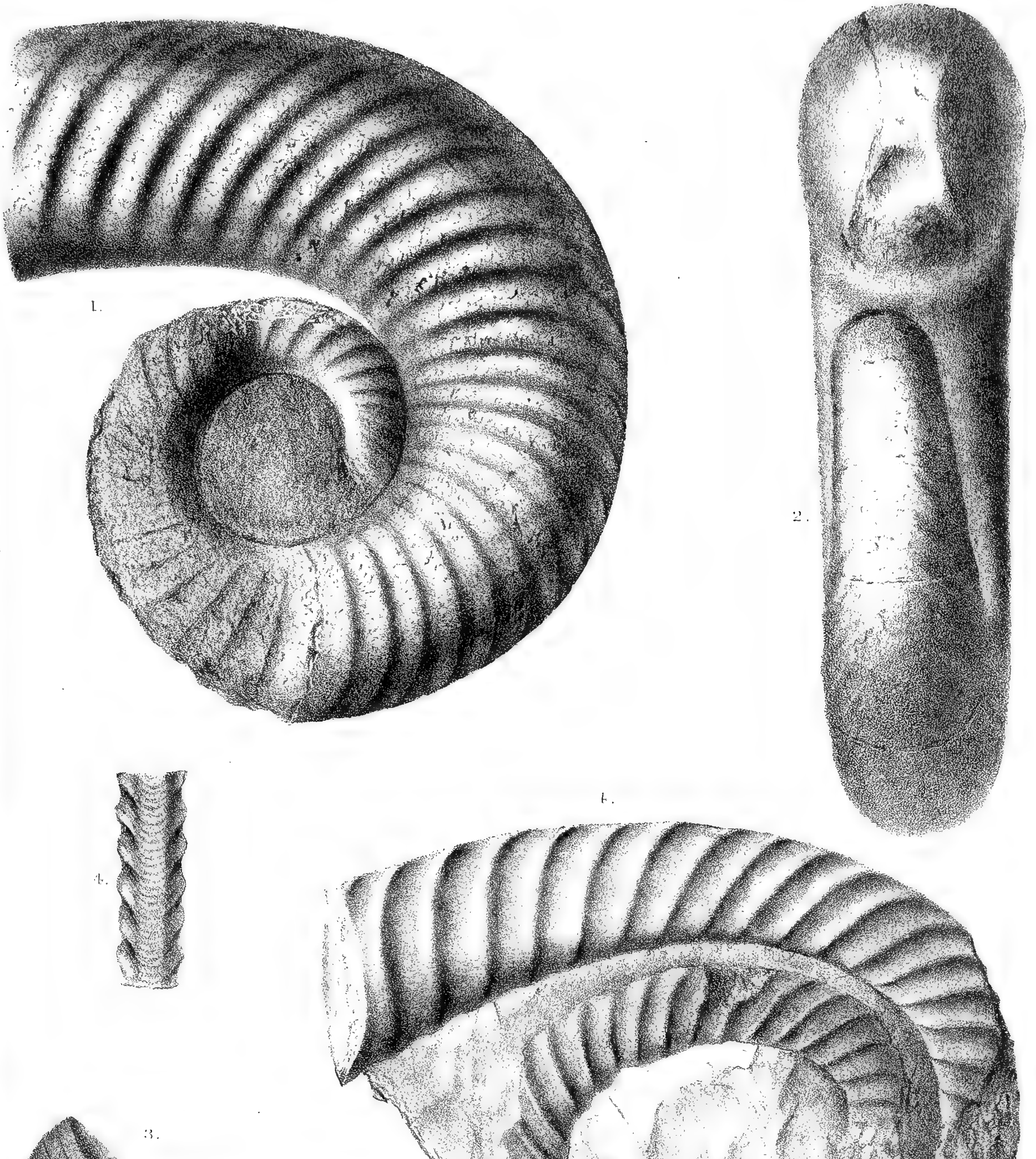
A. Gawan, del et lith.

Mintern Bro's imp.

Plate XXXI.

Fig.

1. Trochoceras giganteum.—From the Lower Ludlow. Locality unknown. In the Museum of the Geological Society. Sowerby's type.
2. *Ibid.*—From the Lower Ludlow, Leintwardine. In the Museum of Owens College, Manchester. Showing the asymmetry and the contracted aperture.
3. Trochoceras tortuosum.—From the Lower Ludlow, Welchpool. In the Museum of the Geological Society. The portion above the dotted line (x) has been reversed and the other side of the fragment drawn. *a,* the septal surface.
4. Lituites arietinus.—From the Lower Ludlow, Ledbury. In the collection of Dr. Grindrod. *a,* view of a portion of the front.



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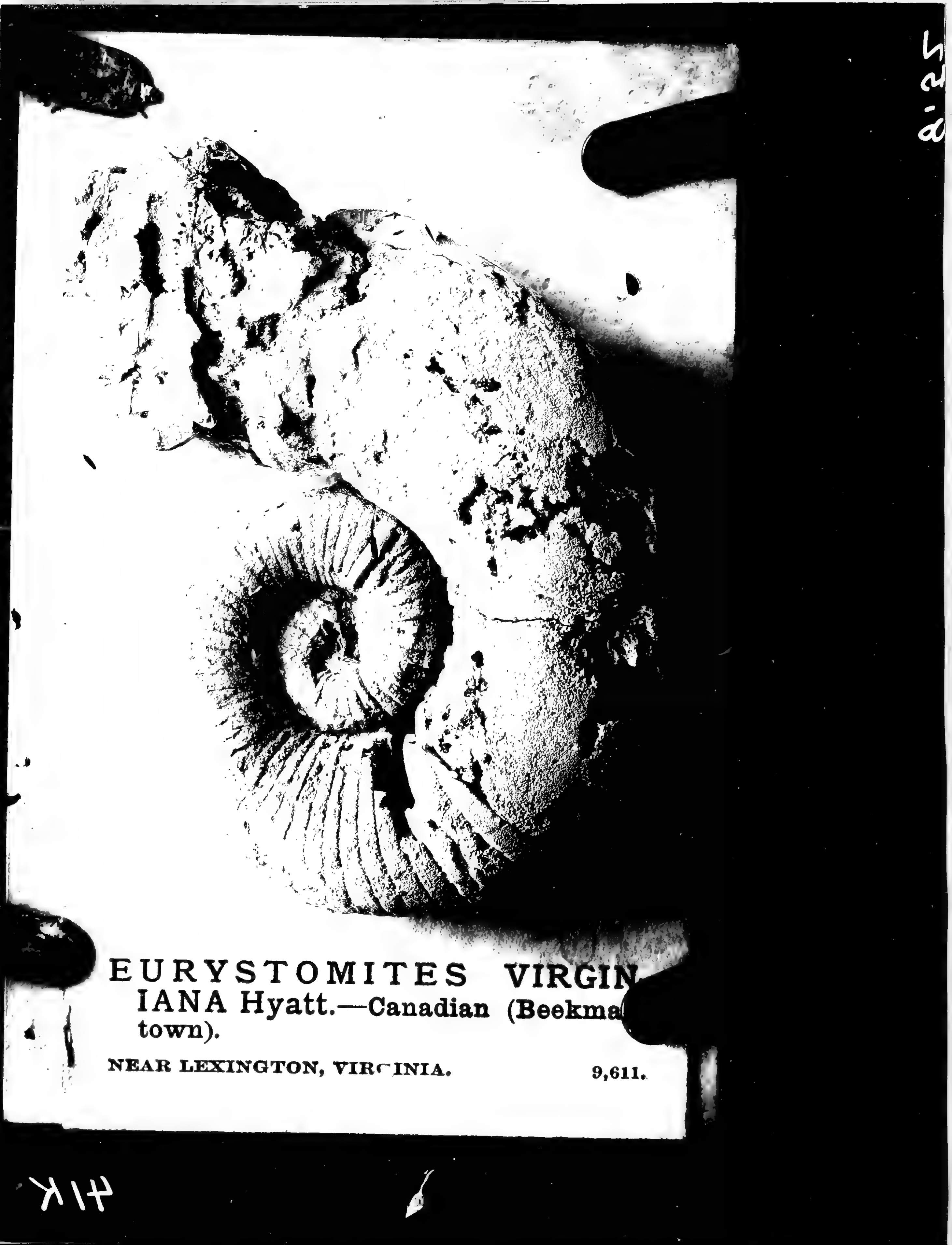
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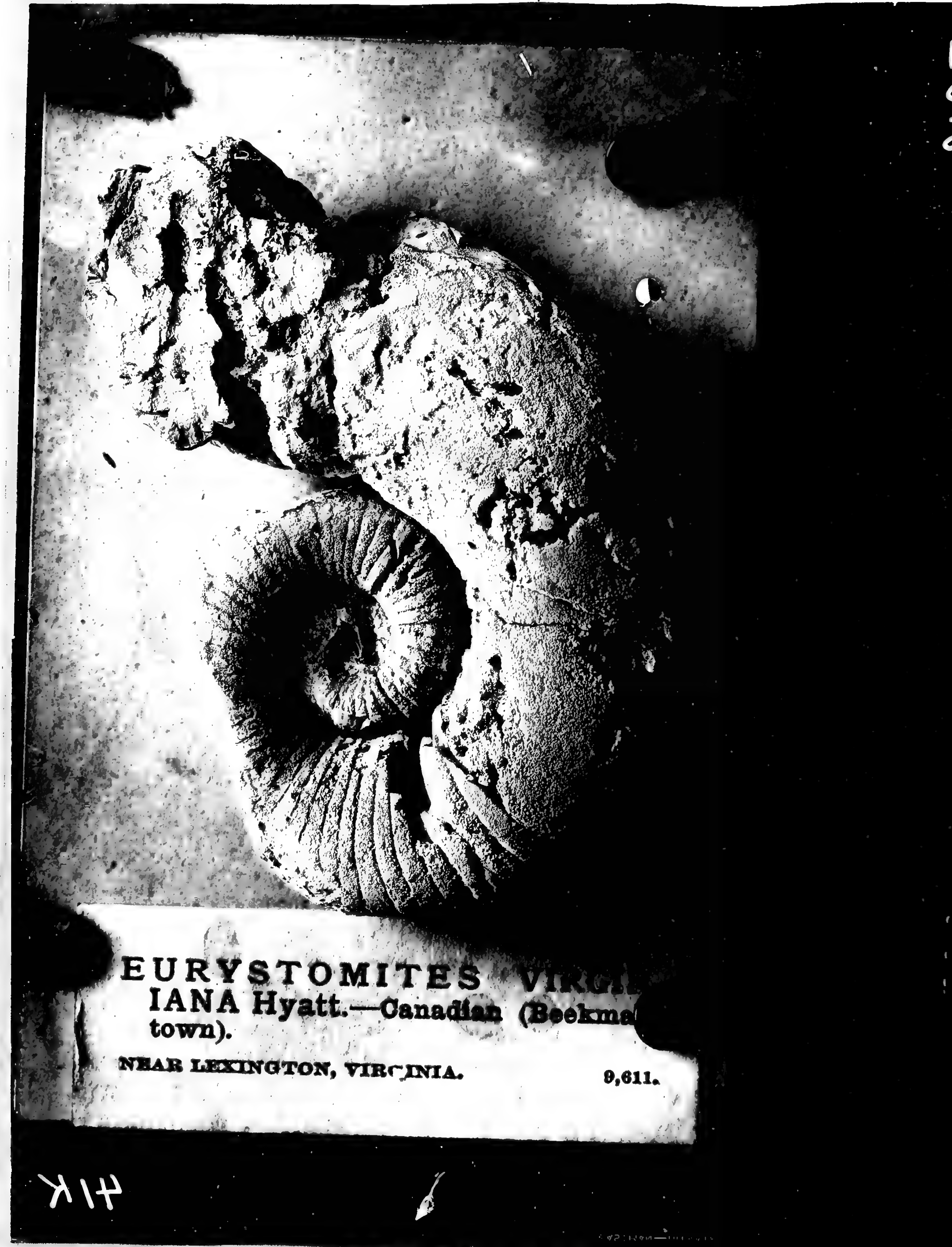
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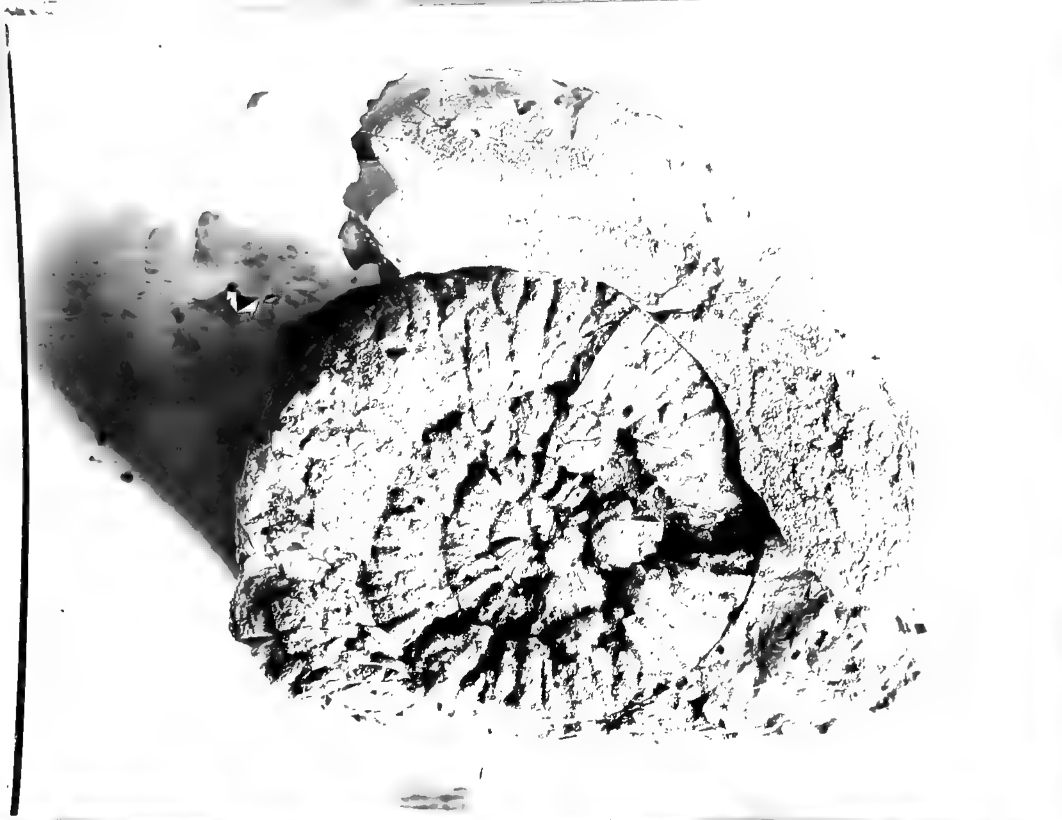


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